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ACETYLENE GAS

HOW GENERATED – HOW USED

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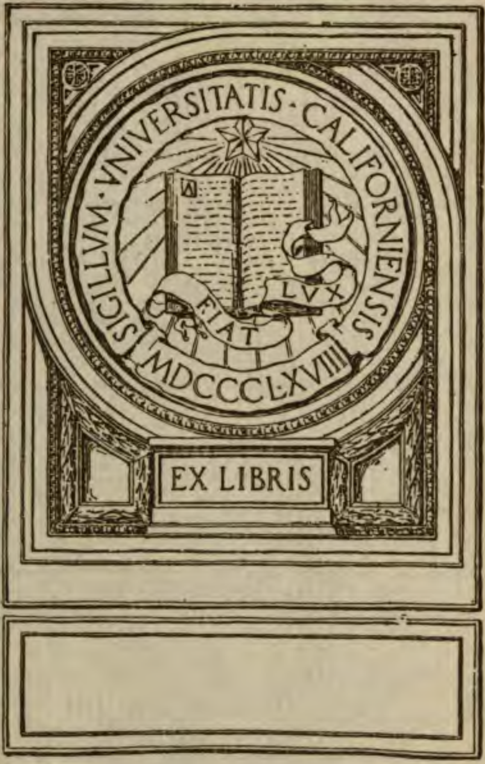

PRACTICAL

Hot Water Heating
Steam and Gas Fitting
Acetylene Gas, How Generated, How Used

ILLUSTRATED

SHOWING THE LATEST AND MOST APPROVED DEVICES AND APPLIANCES USED. THE VALUE OF ACETYLENE GAS AS AN ILLUMINANT DISCUSSED FROM VARIOUS POINTS OF VIEW; EVERY CLASS OF GENERATOR DESCRIBED. GAS BURNERS AND PIPING; ALSO THE BEST AND QUICKEST METHODS OF DOING HOT WATER HEATING, STEAM AND GAS FITTING, UP TO THE PRESENT DATE

BY

JAMES J. LAWLER

AND

GEORGE T. HANCHETT, S.B., M.A.I.E.E.

Revised Edition

NEW YORK
EXCELSIOR PUBLISHING HOUSE
McKeon & Schofield, Proprietors,
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PREFACE.

I AM fully aware of the existence of many excellent works on steam and hot-water heating, also on gas-fitting, and by able men. Still, I believe I can talk to the average mechanic in a way that he will more fully comprehend in much less time all the methods and principles involved in the proper construction of hot-water and steam heating plants, and all necessary information in gas-fitting, than he can learn from many of the previous works published, to my knowledge.

One of the great faults with most writers on mechanics, is, that they become too scientific and use too many technical terms for the average mechanic. Time is too short for him, and, besides, the average mechanic has not got it to waste on the germ theory or the microscopical principle of things. Those are all very well for the student, the scientific professional man, or for any one who has plenty of time and nothing to do.

Therefore, my aim in this work will be to make everything as plain and simple as possible; using words and terms such as any one might understand, and not fill up the book with matter that is dry and distasteful to the average mechanic. In speaking to the mechanic in a highly scientific way only confounds matters and makes him

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believe that everything is much more difficult to perform and more dangerous to meddle with than they really are.

With the great perfection of radiators of every description, being so well proportioned, having the proper size inlets and outlets for their capacity for every system of heating, it is not at all necessary for the fitter to bother with the quantity of water to be moved in a given time through the heating plant to get the best and most satisfactory job. Not one fitter in every thousand ever wastes such time. The practical man would have the job finished before that problem could be figured out by the average mechanic; and it would not be correctly figured out by any man, no matter how scientific he might be.

Another nonsensical and unnecessary thing to talk about to the fitter is heat units. What does he care about heat units, and where does he, or can he, bring this into any practical shape? Such matters will be avoided in this work.

PREFACE.

THE chapter entitled Acetylene, How Generated, How Used, is written for the express purpose of putting the user in close touch with the present state of the art. The value of Acetylene gas as an illuminant is discussed from a commercial and spectroscopic point of view. Its methods of manipulation are taken up in detail, and from every class of generator on the market a typical one is selected and thoroughly described. The merits of the various methods of generating Acetylene are touched upon and set before the reader in a thoroughly disinterested way. The good points of each method are mentioned, but the defects are also noted. Up to the present time most of the literature on this subject has been compiled either by those who are directly interested in the generation of Acetylene or by those who are advocates of ordinary gas or electricity. Disinterested information on this subject has been hard to obtain, and it is therefore believed that this chapter will be of great value to plumbers, gasfitters, and prospective users.

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HOT-WATER HEATING.

HOT WATER THE GREAT HEAT OF THE FUTURE FOR DOMESTIC PURPOSES.

ALTHOUGH we may tap the clouds and bring down our supply of electricity free of charge for heat, light, and power, it will still be necessary to use water as the agent through which the electric fluid may be utilized for the purpose of warming and ventilating buildings. For domestic purposes, it is possible to construct a hot-water heating apparatus by which a house can be heated and ventilated to perfection. And it is not possible to do so with any other system. The great advantages which hot water has for heating purposes and the principles upon which depend its successful operation were not very well understood in this country until within the last few years, but the English were awake to its advantages, and have been using it as their best system for more than half a century.

ITS HIGH PRICE DELAYS ITS ADOPTION.

There is another reason why hot water was so long and slow in coming into more general use for house heating, and that was its cost, being very much more expensive than any other system, and, like the custom in all young countries, the cheapest thing will be tried first; but, as it grows older, it learns by experience that the best is the cheapest, even at a higher price. And, until the time arrived when people who could afford such improvements began to see that there was nothing too good for them and were willing to pay for the best, no time was spent by men of brains and education in the development of the water system. But we have outgrown that principle of false economy, and we are now at the place where we have learned by experience that the best is not any too good. We want it and we are willing to pay for it.

A PREMIUM ON BRAINS IN THIS LINE NOW.

As a natural consequence, where there is a demand from the people for something better in one system or another, the greatest minds go to work at once in their particular line, and the combined results are something wonderful. The Americans are the greatest people on the earth to appreciate improvements, and, therefore, further encourage those who are gifted with inventive genius to continue their work in the line of discovery, feeling assured that if they produce something with merit, it will be substantially appreciated. And, since Americans pay well for American brains, the wonderful improvements made in the line of sanitary appliances for domestic purposes within the last ten years show that they have lost no time and have outstripped every other country on the face of the earth, no matter how old it may be.

HOT-WATER SYSTEM WITHIN REACH OF ALL.

With the great improvements made in recent years, particularly in special material and machinery, it is now possible to produce and place upon the market hot-water heaters of superior quality, even as low in price as some of the inferior heating appliances. And, consequently, there should be no excuse for not having the best and most sanitary heating system in our homes. The hot-water system for house heating has so many advantages over either steam or hot air in any shape, that there is scarcely any comparison. Of course, when we speak of the hot-water system, we mean a system that is properly constructed, using the latest improvements in the line, and carrying out every detail as intended by the heating engineer, who thoroughly understands his system and knows just what it can do. While the causes of the circulation of water through the pipes and radiators in a heating plant are some of nature's most simple principles, still there are hundreds of persons who represent themselves as steam and hot-water fitters, and undertake the work, who do not know one iota of the principles of circulation.

EVERY MAN TO HIS TRADE.

It is very easy to have a system condemned through ignorance, no matter how good it may be, and it is very poor policy to go to the harness-maker because he works with leather and have him make us a pair of shoes. There is no difference between that and getting a tinsmith or a machinist to do our steam or hot-water heating. And if we do go to such incompetent persons and have our work done, we should not condemn the entire principle or system of heating if we discover that the work is not satisfactory; and, as a rule, that is the discovery we will make, while we are to blame ourselves. Therefore, if we start out right, employing men of experience who make a specialty of this line, there will not be much trouble in getting exactly what we want and with the most satisfactory results. Nature has given some principles to water which specially adapt it for the conveying and transmitting of heat, and these principles have been taken advantage of for a thousand-and-one things, and among them the heating of houses.

WE CAN HAVE ANY TEMPERATURE WE WANT.

One of the best principles in the hot-water system, is, that we can get any temperature we want. If we wish a temperature of sixty degrees, we can have it; and if we want eighty degrees, we can also have that, or any other degree. And it is also possible to hold the desired degree of heat at a more uniform temperature than can be done by any other system. A uniform temperature for domestic purposes is the great aim of heating engineers. The hot-water system is very much less liable to leakages in the pipes and radiators than in the steam system, for the reason that there is much less expansion and contraction of the pipes to cause it by the sudden and extreme changes in temperature. There is no possibility of noise from the water, and the heat is never disagreeably or dangerously hot, but mild and more natural, so that it can never destroy the air which it must heat. There is never any dust or ashes floating through the house from the hot-water heater, and, as a rule, a hot-water system will last ten times as long as any other heating arrangement; water preserves the iron. There are many other strong reasons why water is the grandest system for domestic heating and will be the great heat of the future.

CAUSE OF THE CIRCULATION OR MOTION OF WATER IN A HOT-WATER HEATING APPARATUS—HEAT THE MOTIVE POWER—EXPANSION AND CONTRACTION, WITH THE LAWS OF GRAVITATION, THE CAUSE OF MOTION.

Water in a hot-water heating apparatus is caused to move or rise and fall by its change in temperature; and fuel, in a state of combustion—whether coal, gas, or any other material used for fire—applied to the boiler or vessel containing the water is what causes its change in temperature.

Electricity can also be used for heating water; but this is virtually the same thing, as it is produced by a power from some source. Therefore, heat produced in any way, applied to the water, will answer to change its temperature and cause it to circulate.

Water does not rise and fall by its particles becoming lighter or heavier, as stated in many works on hot-water circulation. Matter of any kind never changes its weight; but matter of every kind changes its size and place. This is the case with water. When any of its particles are caused to move, or rise, by the application of heat, they are simply made larger in size; that is, they expand, taking up more room than they formally had before being heated, and therefore have more buoyancy power than the particles that have not been heated to as high a temperature, and consequently rise and fall according to this law.

For example, let us consider how the common paper balloon is sent up so high in the air. We buy the balloon and candle, or whatever goes with it to light and heat it, from the dealer. Now, we do not receive it in the shape it is sent up in the air, all opened out. That would take up too much space for the balloon dealer, and there would not be room in his store for very many in that shape. The very first thing we do with it is to change its shape. It is opened out and a lighted candle is placed on the inside. In a short time the heat from the candle expands the air on the inside, and the balloon becomes larger in size. Now, we have added no material of any kind to the balloon to make it larger, simply the heat. It continues to grow larger until it displaces an amount of air, the specific gravity or weight of which would be as much as all of the material from which the balloon is made, including the candle and the air on the inside. If we then took the balloon and placed it on a scale it would show or indicate no weight at all. Now, has the balloon become lighter, because it does not show any weight on the scale? We have taken nothing from it to make it lighter. In this stage, it is what might be called a balance hanging in the atmosphere. Now we continue the heat and make it still hotter, and it continues to grow larger, and is now what might be called lighter than nothing. And of course that could not be. Now let us make it fast to the scale, and in place of weighing down the scale it will lift it up, and during these different changes it has never changed its own weight.

The balloon goes up in the air, and will continue to rise as long as the expanded air on the inside occupies the same space. After a little time the candle burns out or the light extinguishes, and now we have nothing left to keep up the heat. The cold air on the outside soon cools the air on the inside, and as it cools it contracts, and the pressure of the atmosphere, pressing on the outside of the balloon, begins to collapse it; and as it grows colder it becomes smaller and soon falls to the ground again. We are now back to where we began with the balloon, and it is still the same weight. The rising and falling, or circulation, of water in a heating apparatus works on the same principle, and the balloon represents one particle of water in the system.

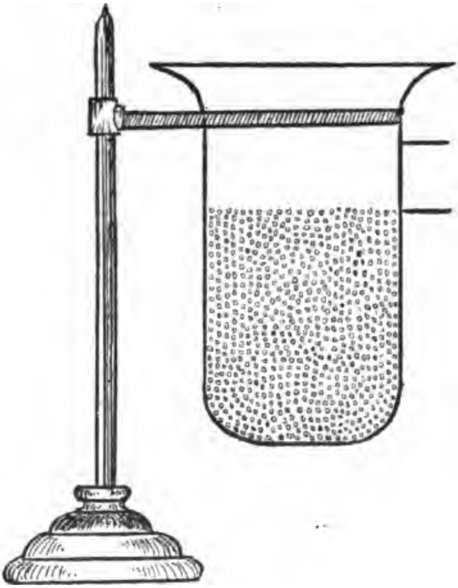

Fig. 1.

To further illustrate the principle upon which hot water circulates, we will consider Figs. 1 and 2 to be glass vessels nearly filled with water; and we will suppose we can see the particles as they really are in the shape of small balls. In Fig. 1 they are all about the same size, and the water in this vessel being cold and all of the same temperature, the particles would naturally be very small compared with what they would be when heated to a high temperature. And each one being the same size, with identically the same power, there could be no motion or circulation. One could not rise above another and revolve back again to its former place. This is why there is no perceptible motion to cold water in a vessel.

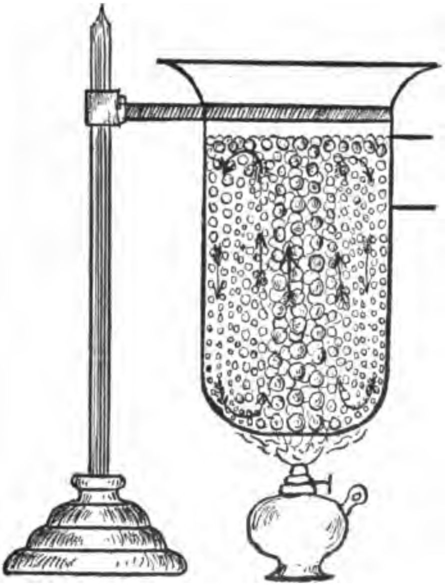

Fig. 2.

Now we light the lamp as shown in Fig. 2 under the vessel containing the same water, and the very moment the heat from the lamp affects the temperature of the water, that moment the particles receiving the heat begin to expand and become larger. From the time they begin to grow larger they also begin to move.

In this vessel the particles of water are shown as being of different sizes, those being the largest directly above the heat, or lamp, because, having received the most heat and not yet coming in contact with any cooling surfaces to reduce their temperature, they rise to the highest point in the vessel, or heating system, and make room for other smaller particles to take their places. So they roll up and down like a lot of little marbles. And their velocity, or the rapidity with which they travel, or rise and fall, depends upon their temperature and size. A cold particle takes away part of the heat from the hot particle, or the hot particle gives some of its heat to the cold particle. So that in a little time they all become of the same temperature and size, without coming in contact with any other surfaces than themselves; so the laws of gravitation is the cause of this action.

If it could be possible for us to see a picture of the particles of water as they are in a heating apparatus while in operation, we would see the most wonderful piece of shading, caused by the different sizes of the particles, that was ever seen. The greatest artist that ever lived could draw nothing that would in any way compare with it. It is most essential to know the philosophy of the circulation of water in a heating system in order to avoid mistakes and carry out its application in any hot-water heating apparatus.

In Fig. 2 it will be noticed that the smallest particles are on the sides near the bottom. That is because, after making a revolution or circuit through the vessel, they have lost most of the heat they had, and are consequently the smallest. This is exactly what occurs in a hot-water heating apparatus. The particles expand again as they receive the heat, and thus keep up a motion practically called circulation.

The water, being expanded in the vessel in Fig. 2, is shown to stand higher in the glass than in Fig. 1, because the particles take up more room. This is the reason why it is necessary to have an expansion tank on a hot-water heating plant or apparatus, to make room for the water when it expands.

CIRCULATION OF WATER THROUGH PIPES IN A HOT-WATER HEATING APPARATUS—WHERE THE HEAT SHOULD BE APPLIED TO PRODUCE THE BEST CIRCULATION—FRICTION OF WATER IN PIPES—ILLUSTRATING HOW THE CIRCULATION IS RETARDED IN THE PIPE SYSTEM BY DIFFERENT CURVES AND BENDS.

In the cut, Fig. 3, we show what might be called the cylinder separated, or made into two parts, representing two pipes, having an enlargement on one side which might represent the boiler in a heating system. The lamp or fire applied to this part of the pipe will cause the water to circulate quite rapidly. The water in this form of piping will have very little friction, as both legs are nearly perpendicular, with the exception of a little on the right-hand side, at the bottom, as shown by the

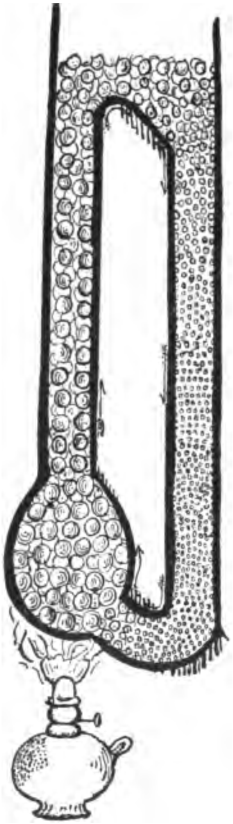

Fig. 3.

straight marks. The water in falling down the right-hand leg has little or no friction until it reaches the bend. Then the particles of water must slide down

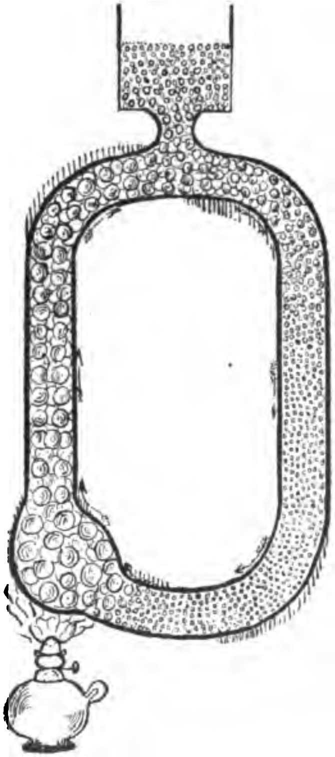

Fig. 4.

that part of the pipe which has a tendency of retarding the circulation. There is also a little friction in the downward flow on the right-hand leg, near the top, as shown by the small vertical lines. We will now take another form of piping as shown in Fig. 4.

This has exactly the same number of feet of pipe and the same diameter as in Fig. 3. But this is a different shape; it being oval on top and bottom, with the lamp or heat applied in the same way. The opening on top of the bend would represent an expansion tank, and the difference in size of the little balls or spheres which represent the different particles of water show the dif-

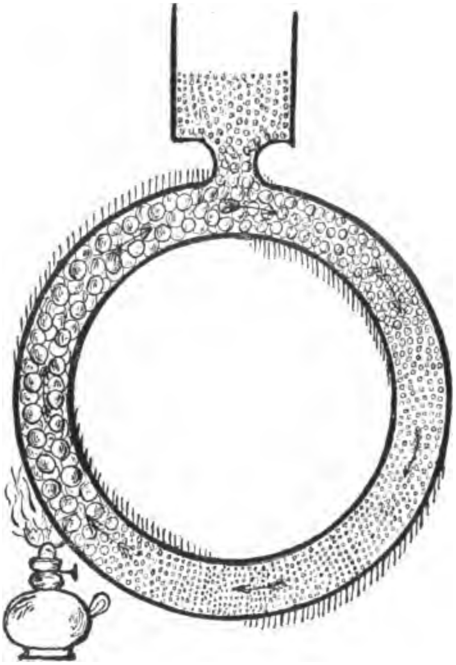

Fig. 5.

ference in the temperature, and the direction of the arrows shows the direction in which they move around the system. It will be noticed that in Fig. 4 there is much more friction than in Fig. 3, as the vertical lines here again show. So that the same amount of heat applied in this case would not do as much heating as in Fig. 3. We take another step, and we

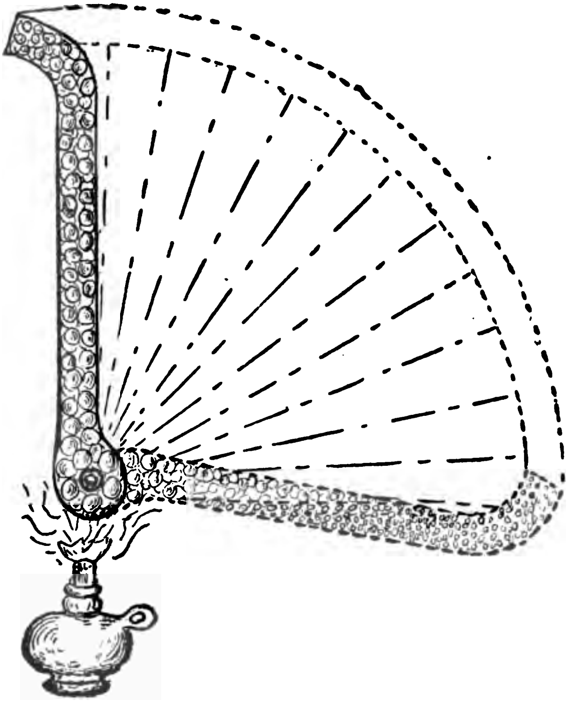

Fig. 6.

form the same pipe into a circle having the same length and capacity, which is shown in Fig. 5.

Its principle of circulation is the same as the other systems, but the difference is in the friction, which is very much more than in Fig. 4, as shown again by the vertical lines. In this case the water's motion is retarded at nearly every part of the circle. It will now be seen that the more we depart from vertical lines of piping in a hot-water system the more we retard the water's motion. And should our flow pipe fall below a horizontal line, as shown in Fig. 6, the circulation would stop entirely.

In Fig. 6 is shown a section of a flow pipe, and for illustration we place it on a pivot or hinge near where the heat is applied to it, which would be the same as the boiler. Now, we bend it over, as shown by the dotted lines in the half-circle, until its outer end comes below a horizontal line. For every degree of angle that we move the flow pipe away from the vertical line is added more and more friction to the flow of the water, until brought to the lowest point, as shown, when its flow stops entirely. Of course there is a certain amount of friction in all pipes, no matter how they are placed, even in the vertical lines. Even friction is one of Nature's great principles, and is taken advantage of and utilized for many things. But we do not want it in hot-water heating; so that the great aim of the fitter must be to construct his heating plant in a way that there will be the least possible friction of the water through the pipes, in order to obtain the best results when completed.

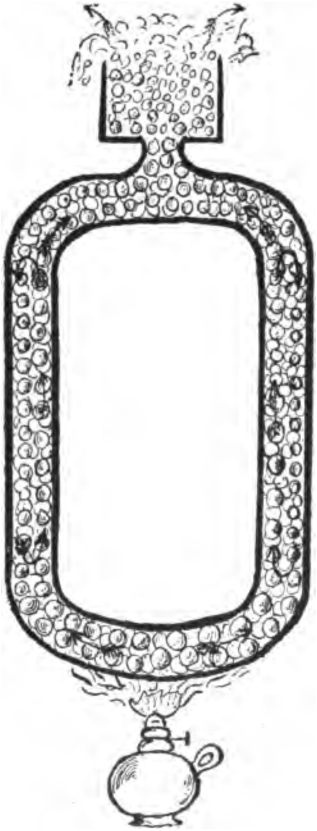

Fig. 7.

CIRCULATION RETARDED OR STOPPED BY THE IMPROPER APPLICATION OF THE HEAT.

In Fig. 7 we show the U-shaped pipe again with the heat applied in the centre at the bottom. This is a bad way to apply the heat, as it stops or prevents circulation, and the water is forced up both sides of the system, forming into steam, and overflows the expansion tank. But this more particularly applies to the construction of the boiler for hot-water heating.

THE FIRST JOB OF HEATING PRACTICALLY APPLIED.

We have now gone over the principles and causes of circulation step by step, and are ready to begin our work in a practical way, and will start with a very small job or plant.

In Fig. 8 we show a boiler on one floor and a coil for radiating surface on the floor above, to heat only one room. *A*, *B*, *C*, and *D* represent the boiler, flow pipe, expansion tank, and return pipe, and the direction of the flow of water in this little system is shown by the direction of the arrows. It will be noticed in Fig. 8 that we have now placed a boiler in the exact position as when the pipe was enlarged to receive the heat in Figs. 3, 4, and 5; so that it is still the same principle carried out in order to produce the circulation. *A* is the heater, or boiler; *B* the flow pipe connected to top of boiler and carried up to expansion tank, *C*, and connected to the side of the tank, leaving some room above for the expansion of the water. We then connect the return pipe, *D*, to the bottom of expansion tank and carry it through the room in the shape of a coil, gradually pitching down in the coil, and then descending to the bottom of the boiler.

This is the true and best principle of a hot-water heating system, and the nearer we can carry out this principle in the more complicated plants, the better the results will always be.

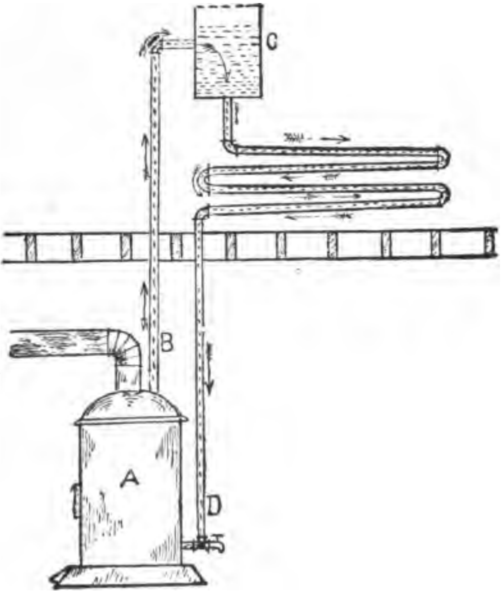

Fig. 8.

The coil in Fig. 8 has some special work to do besides being part of the return pipe; it is to give off its heat for the purpose of warming the room; and the very work which it has to perform is an advantage to produce quicker circulation, because, as it loses part of its heat, its particles contract again and become smaller than the hottest particles rising in the flow pipe, and, of course, drop or roll to the bottom, as described before. So what I wish to impress in the mind of the student is, that all radiating surface—that is, radiators or any pipe intended to warm some place—is, or should be, simply part of the return pipe in a hot-water heating plant.

Flow pipes in a rising position should never be used for heating surface, as the good such heating surface might do in one place would be more than lost in some other regular radiating surface by retarding and cooling the flow of water.

In this little plant it might be noticed that we have no valves of any kind on the pipes. In this case there is no use for valves; in fact, a valve of any kind would be a detriment. There is no place in this system for air to lodge, as it can rise through either the flow or return pipes and escape through the expansion tank. And it would not do to put valves on either the flow or return pipes, as we would then have no escapement or outlet from the boiler. So that the less valves that are necessary on a hot-water heating plant, the less trouble there will be with it and the better the results will be from it.

In Fig. 9 is shown another plant, a little more complicated, having two radiators placed so as to heat two rooms; and, in some respects, its principle differs from that shown in Fig. 8.

In this case we connect our expansion tank in a different way, and we also use valves on the radiators, so that the heat can be turned off from one or the other rooms if desired without interfering with the fire in the heater or boiler.

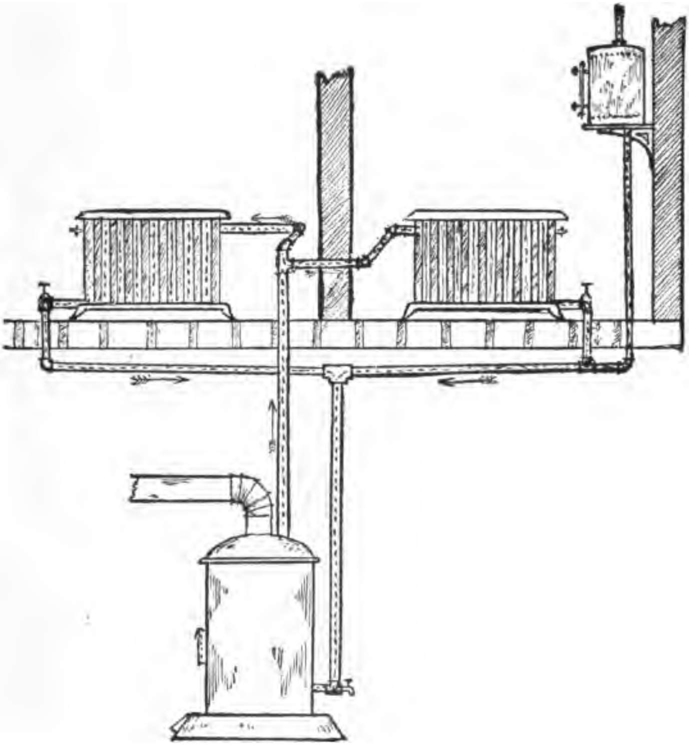

Fig. 9.

It will be noticed in this plate (Fig. 9) that we also use air valves on the top at the outlet end of each radiator. These valves are for the purpose of letting out the air, which always accumulates at the highest point of a pipe or radiator in a hot-water heating system, and will stop the flow of water unless allowed to escape either through an air valve at that point or a pipe carried directly to the expansion tank. And in this job we connect the expansion tank to the system by a pipe about one inch in diameter, which joins the return pipe near one of the radiators, as shown. This will work all right, but it is always better to take the expansion pipe directly from the bottom of the boiler and connect it with nothing else but the expansion tank; and, particularly, if we feed the system with water at the expansion tank, or in such cases as where automatic water feeders are applied to the expansion tank.

These two systems, as shown in Figs. 8 and 9, are what we call the low-pressure or open-tank systems, and in these cases we leave the outlet from top of expansion tank open to the atmosphere; that is, we put on no stop-cock or valve. And to avoid the overflowing of water doing damage, we carry this outlet from top of tank either out through the roof of the building or down into some sink.

In Fig. 9 we begin to run into tees or branches; and I wish to call attention as to how we should carry these branches to the different radiators, for two purposes: first, to be sure we get as much rise in the flow branches as we possibly can from where we take it off the vertical line or riser to where it enters the radiator, in order to get the quickest flow of the hot water with the least resistance; and next, to carry the branches in such a way that the expansion and contraction of the long vertical pipe or riser will be provided for. As shown in this Fig., there are two pieces of pipe between each branch on the flow pipe, with their elbows, and some little distance between where the branch is taken off the riser and where it enters the radiator; so that when the riser expands and becomes longer, as a rule, its movement will be upward, because the foot of the riser is generally resting on something solid, such as pipe-hangers or something else, and, consequently, it cannot go downward. And the riser, or flow pipe, rising as it will when it becomes hot, makes a swivel or swinging joint of the branch when made as shown, so that there will be no lifting or moving of the radiators from this cause or straining of the pipes.

In the return pipe, as shown in this Fig., we do not get the swivel movement for expansion, but we have longer horizontal branches; and in this case we get what might be called the spring in the pipe, which answers all right for the expansion in the vertical line of return pipe.

COMPLETE PLAN OF A HOT-WATER PLANT AS CONSTRUCTED IN THE AVERAGE MODERN HOUSE.

We might as well begin now and fit up a complete plant, such as will be found in the average modern house; and, as shown in Fig. 10, having the boiler located in the cellar, with direct radiators in the different rooms on the first and second floors, and the expansion tank located in the attic.

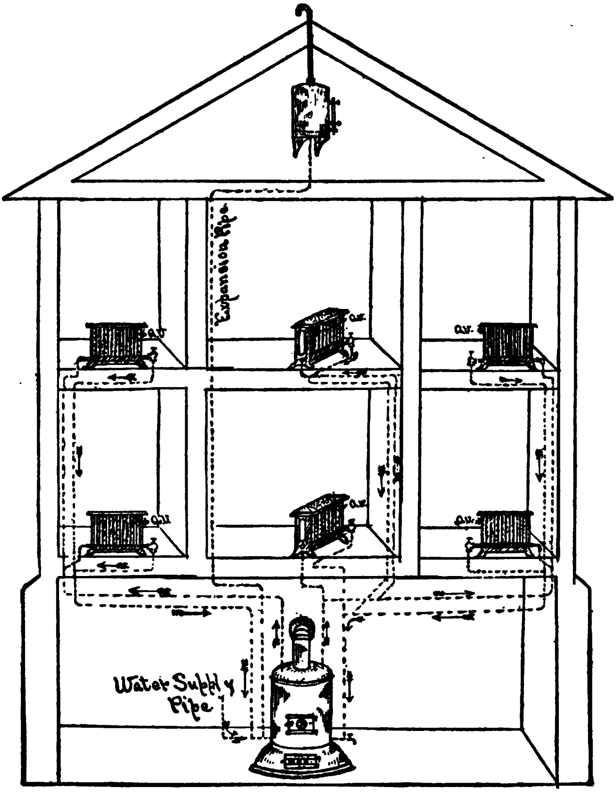

Fig. 10.

We will first locate our boiler; and, in order to avoid long horizontal lines of pipe as much as possible, which are always a great detriment to the flow of water, we would have to locate the boiler in the centre of the cellar, as shown in Fig. 10, providing there was nothing in the way to hinder us from doing so; and, if we cannot locate it there, we should place it as near that point as we possibly can.

It quite frequently happens that in places where we have room for the boiler in the proper location, the chimney happens to be off in some other part of the cellar, which is bad for the general working of the apparatus. In such cases I have found by practical experience that it is better to run a long horizontal smoke pipe from the heater to the chimney than to have long horizontal flow pipes from the boiler to the risers or radiators. Therefore, to properly locate the chimney for the heating apparatus in the building of a house is an important matter that should not be overlooked by the architects.

We will continue our work in constructing the plant (Fig. 10). Having located the boiler, with reasons for such location, we will now proceed with the other work.

Where direct radiators are used in the ordinary dwelling-house, it makes very little difference in what part of the room the radiator may be located, providing it has the proper capacity and is not boxed in by shelving or cornered up with furniture so that the air of the room cannot circulate around it.

In locating the radiators there are several things to be considered, and the best we can do is to average these things up, and not favor one to the great detriment of the other. To entirely please the lady of the house with the location of the direct radiators, we would have a hard job on our hands. They would have to be so small that they would take up no room at all, because she has not an inch to spare for her different pieces of furniture. Then, besides, she does not want them located where they can be seen, and, of course, she would not have any of the pipes show in the room for the world! But she insists that the room must be well and satisfactorily heated in the most severe weather, otherwise she will not pay for the work.

Now, this is a very important matter, and the fitter who does steam or hot-water work will, sooner or later, meet more or less of such trouble. The lady does not know the many obstacles that you have to contend with in order to get the best working results, even in the most favorable situations, and, furthermore, she does not care. She only looks at her own side of the question, or what she thinks to be to her best interests; and this is a place where you will have to use your best piece of diplomacy. You must not overlook the best practical working of the system for the appearance of rooms, in order to please the owner of the house, who, as a rule, knows nothing about such things.

Therefore, having made the best arrangement we can in regard to the location of the different radiators, we begin to connect them with the boiler. In Fig. 10 the flow and return pipes are shown by dotted lines, and the direction of the arrows indicate the direction of the flow of water in the system. If the risers are to be exposed—that is, not inside of the plaster—the entire job can be completed at one time; and in such cases it is customary for the fitter to begin on his flow pipes first, perhaps, because some parts of them are placed higher up on the ceilings than the return pipes. In Fig. 10 we take out two flow pipes from the top of the boiler, as shown, one on each side; and as we have to run each side of the boiler with our mains, this plan gives each side an equal chance to receive its proper proportion of hot water, and it also makes it better for the boiler, in regard to the flow of water through it. And in this case we do the same thing with our return pipes, having one on each side carried down and connected at the bottom of the boiler. This is also very much better than to bring back all the return water through one connection at the boiler, as it has a tendency to more fully equalize the circulation of the water through the boiler. In running our horizontal lines, we must bear in mind that it is necessary to give them a good elevation, gradually rising from the boiler to the radiators. It is a good plan, and one that looks, perhaps, the best, to carry the return lines on the same grade as the flow pipes. It will be noticed that the proper precaution or provision is made in this pipe sys tem for the expansion and contraction of the pipes. Each end of every branch is loose, so as to move or swing, as the expansion and contraction may cause, without straining or injuring anything. In regard to the size of the flow and return pipes of a hot-water heating plant, it has become the custom to have the flow pipes the same size as the return pipes, and hot-water radiators are tapped out for the same size connections on both inlet and outlet. At this point I might say a few words in regard to the movement or velocity of the water through a heating apparatus, and the effect it might have on the size of the flow and return pipes. We know for a fact that the same amount of water that rises through the flow pipe returns to the boiler through the return pipe, and we also know that each particle of water rising in the flow pipe of a hot-water heating apparatus travels many times faster up than the same particle travels down through the return pipe; so we have a great check to the circulation. And the question might arise here whether it is better to have the flow and return pipes the same size or not. However, we will not complicate matters by going down too deep into this subject at this time.

RADIATOR CONNECTIONS.

The radiator connections used on a regular hot-water plant consist of one radiator valve with union, one union elbow, and one air valve. It makes little difference, if any, at which end of the radiator the valve for controlling the heat may be located. Which ever happens to be the handiest or easiest to connect with the pipe, that is the end at which I would place the valve. On the other end, whether it is the flow or return, we place a union elbow. This makes it easy to connect or remove the radiator at any time without breaking any connection. I might say that it is also the custom and perhaps an advantage to connect the flow pipe to the nearest end of the radiator, so as to have as short a run as possible to it. On the outlet end, at the top of each radiator, is placed an air valve as marked in the figure, *A V*. This is, as stated before, to allow the air to escape, in order that the radiator might be entirely filled with water. The best valve to use for this purpose, according to my experience, is the key valve: one that is opened and closed by the use of a small key, so that children cannot turn it and allow the water to escape, which might do much damage to the carpets and ceilings.

THE EXPANSION TANK.

Having our boiler set, the flow and return pipes all run, and the radiators connected, we will now connect up the expansion tank. And as a rule this is left for the last. In Fig. 10 our expansion tank is placed in the attic. This is because there is generally plenty of room to spare in that part of the house; and, besides, it is out of sight. It is not necessary to place the expansion tank so high; it is only necessary to have it above the highest radiator. And where there is no attic room, or where the attic is too cold for the tank, it is placed on the wall in any convenient place in the house, so long as it stands above the highest radiator. The proper way to connect the expansion tank is to carry a pipe, as shown in Fig. 10, from the bottom of the boiler directly to the bottom of the tank. This pipe should never be less than a one-inch pipe, and should never have a valve or stop-cock in it, so that the flow of water between the tank and boiler could not be stopped. To provide against any excess of pressure, or an overflow of the water doing damage, we carry an outlet pipe from the top of the expansion tank up and out through the roof of the house, as shown. Or this pipe may be carried down from the top of the boiler and enter into some waste pipe or over a sink. And this pipe should in no case have a stop-cock or valve in it that could not be opened by the pressure from the tank. The expansion tank is provided with a glass water gauge, so that we can see when the water rises to that point in the system. In filling the system with water we connect to the water service pipe in any convenient part of the cellar, and carry it to the bottom of the boiler, with a stop-cock near the boiler, so as to be handy to operate when necessary. In some places where the tank is not supplied by an automatic water feeder, a small pipe is carried down from the side of the tank, near the bottom, to the cellar, and is used as a tell-tale pipe, so that we will know when there is enough water in the apparatus without going up into the attic to look at the glass gauge. And in some cases we use an altitude gauge placed on the boiler, which indicates the height of the water. And by looking at this gauge we can also tell whether water is required or not. The best and safest thing to do with the expansion tank is to place on it a reliable automatic water feeder, so that you may not be bothered about the amount of water in the system. Everything being now connected, we turn on the water into the boiler, and allow all the air to escape out through the radiators until they are filled with water. The water having risen so that it shows in the glass gauge on the expansion tank, it will now be ready to start the fire.

Before we start the fire I wish to call attention to one very important thing, and that is, the blow-off or draw-off cock at the bottom of the boiler. As will be noticed in the Fig., on the right-hand side, near the bottom of the boiler, is a draw-off cock. This, of course, is a necessary thing in order to drain the boiler in the case of having to disconnect radiators or having repairs of any kind to make But it should never be connected directly by a valve or stop-cock to the sewer or any closed drain, but placed over an open waste connection, so that should the valve or cock be opened by accident, or otherwise, some one would have a chance to notice the water running out of the boiler before the entire system became dry. I have seen many boilers that were entirely destroyed for use through the blow-off valve being accidentally opened and not discovered until the fire had burned out the boiler, and in some cases set fire to the house, by causing the flow pipes to become red-hot. One very good point in favor of having an automatic water feeder on the expansion tank or low-pressure steam boiler is that in such cases as just mentioned, in the blow-off valve being left open, the automatic water feeder would be the cause of saving the boiler from being totally ruined, as it would in a great measure keep the boiler cool until the trouble was discovered. Having properly adjusted the smoke-pipe with the boiler and chimney, and made sure that there was a good and proper draft, we light the fire; and after examining all the pipes, fittings, and connections, and made them perfectly tight, we are now ready to put the finishing touches on, and bronze the radiators, also all exposed pipes above the cellar, and in the cellar to paint all the castings and pipes around the boiler. The best thing to use for this is asphaltum varnish.

It is quite an important thing to know how to properly bronze the radiators. In the first place, to make a good and lasting job, and also cheap, and not to daub up all the plastered walls or woodwork by spattering the bronze all over the room, which is so often seen, take a large piece of paper or cloth and fasten it behind the radiator, and also cover the floor all around the radiator with the same material. If the radiators are to be finished in gold bronze, first apply a thin coat of light yellow paint, and after it is dry apply the bronze. It will take much less bronze and be a very much better job than without the paint and more bronze. And in the same way if the work is to be done in silver or aluminium: first apply a thin coat of light drab paint. Do all this while the radiators are a trifle warm.

MAKING PIPE CONNECTIONS—THE NECESSITY OF HAVING FULL AND CLEAN CUT THREADS—HOW TO PROPERLY MAKE RIGHT-AND-LEFT CONNECTIONS—THE HANDLING OF PIPE—PREPARING PIPE FOR ITS SPECIAL WORK—HOW TO MAKE PIPE COILS FOR STEAM OR HOT-WATER WORK.

It is not enough to know the principles of circulation of water in a heating system, the elevations or pitches of pipes, the expansion and contraction of them, and how to operate the apparatus; we should be as well posted in regard to the best method of making all the different kinds of joints in the pipe system of a plant; not alone for the purpose of making the best kind of a job, but to make it neat, tasty, and also in the shortest possible time. A man may have worked all his lifetime in cutting and fitting iron pipe for gas and water work, or such work as the machinist is often called upon to do in fitting steam pipes between engines and power boilers, and yet such a man would make a most bungling job of steam or hot-water work, also waste half the material, and take three or four times as long to do it, than the man who has been properly instructed in those branches. For hot-water and steam heating work there are special fittings, such as right-and-left elbows; that is, the threads on one end of the fitting turn right, and on the other end left, handed; also right-and-left couplings or sockets, right-and-left nipples, and long or running threads; also properly reduced fittings, so as to avoid using bushings. It is quite an easy matter to tell, in looking at a piece of steam or hot-water piping, whether the man who did it was really practical in that line or not by simply noticing the kind of fittings used. As a rule, the man who is not practical in these lines, or who has not had much experience, appears to avoid as much as possible the use of the several special fittings mentioned above.

The inexperienced man does not use these fittings, for two reasons: First, because he does not know how to use them and make tight connections; and, second, because he does not know that a fitting with a bushing in it is not as good as a properly reduced fitting in one piece; and, therefore, he does not take the trouble to get properly reduced fittings. Another trouble with the inexperienced man, he will often use gas fittings for steam or hot-water work. This is a positive proof that he is not a steam or hot-water fitter. Many men without proper practical experience think that maleable-iron fittings are the best for any purpose. This is a false idea. Maleable-iron fittings are all right and the proper thing for gas fitting or such work as air pipes or for cold water, but they are not at all the proper fitting to use for steam or hot-water circulation work. To stand the action of water or steam in a heating plant, fittings must either be made of pure and tough metal, such as brass or copper, or else of very hard metal, such as cast iron. Where a maleable-iron fitting is used on a hot-water or steam job, as a rule it will in a very short time become honeycombed and cut to pieces by the action of the water or steam. This cutting action of the hot water and steam on maleable fittings appears to be due to both a mechanical and chemical action, which only takes place when heated, as this cutting action does not take place in cold-water circulation.

In Fig. 11 is shown a maleable-iron fitting as it appears after being a short time in use on a steam or hot-water circulating job, with its back cut away from the inside until it leaks; and it is always at this point the most wear or cutting will be found. Now this is the best possible proof of friction of the water or steam in a heating system, and also the best proof as to where the most friction takes place. It might be asked, why does not the action of steam and hot water cut away the pipe itself, which is also wrought iron or much the same material as the maleable fitting? And in reply to that I would say, that it would do the very same thing with the wrought-iron pipe should it be bent as short as a fitting. Therefore never use maleable or wrought iron fittings on a steam or hot-water heating plant of the regular pattern. Maleable fittings are sometimes used on such heating work as passenger cars, but they must be made specially heavy and have long curves. The same cutting effect goes on in this case, but the metal is much thicker, and of course it takes longer to wear through. These special heavy maleable-iron fittings are too expensive for house heating, and besides they are not necessary, as there will be no vibration or heavy straining going on, such as may be expected on a railroad passenger car. Another very bad thing to do

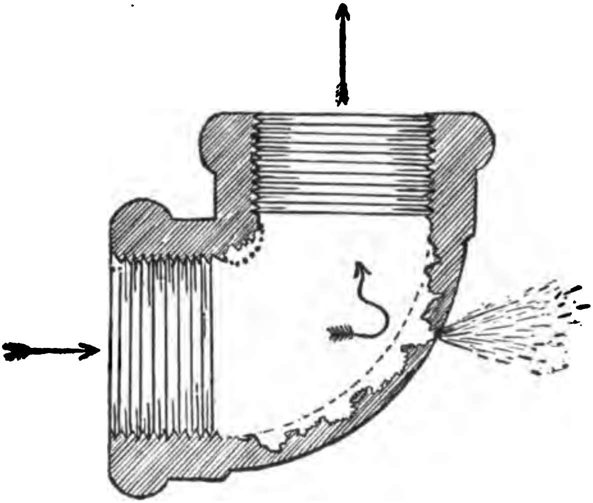

Fig. 11.

in either steam or hot-water heating work is to use lipped unions. There are perhaps more leaks and trouble arising from the use of lipped unions on such work than from anything else about the apparatus, and the practical steam or hot-water fitter knows this, and will never use them.

The Lipped Union.

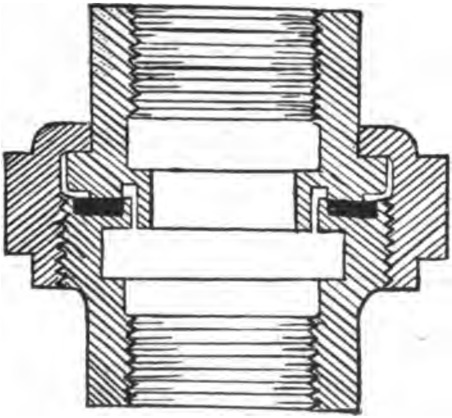

Fig. 12.

In Fig. 12 is shown the lipped union, of which we now speak. The inexperienced man uses this kind of fitting because he thinks it is the easiest way to make a last connection. And perhaps it is to him, but not to the experienced man, as he will find it just as easy, and in many cases less trouble, to make a right-and-left connection in the same place. The great objection to the use of a lipped union, besides being much more expensive than any right-and-left fitting of the same size, is that they require packing or a washer, which contracts and becomes loose; but the greatest trouble with it comes from its construction, not having leverage enough to hold itself together when called upon to stand heavy pressure on straining of the pipes. At times we meet places where we must use a union of some kind, and in such cases we should always use the cast-iron flange union, as shown in Fig. 13.

The Flange Union.

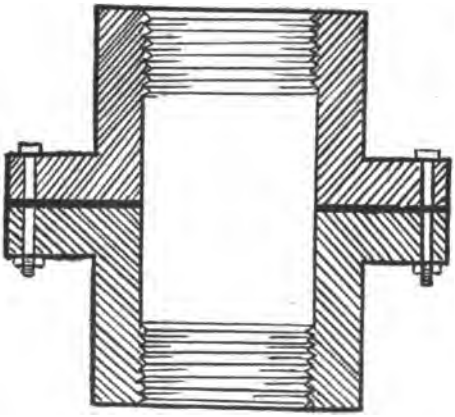

Fig. 13.

This union does not look quite as neat as the lipped union, but in house heating, to which this work is more particularly confined, such fittings are rarely ever required in places where appearance amounts to much, which is in the cellar of the house. When the flange union is properly placed in the pipe with a thin gasket of rubber or pasteboard and drawn tighter together with its bolts, it will not only stand the pressure of the water or steam in the pipe, but it will stand any kind of hard strain or bending that the pipe may receive without becoming loose or causing a leak, and this is because it has a good large surface on its face, which gives it leverage, the bolts being placed near the outer edge.

Another advantage in the flange union is in disconnecting it for repairs or changes at any time, it being much less trouble and taking much less time than the other style of union.

THE RIGHT-AND-LEFT COUPLING.

The right-and-left coupling is a handy, a cheap, and a good fitting to use, and although this is, as a rule, a maleable fitting, it stands the action of the water and steam, because the water or steam in passing through it does not strike it like the elbow or tee, and, therefore, the cutting action does not take place. This fitting is made with ridges on its sides, running lengthwise, so as to make it easy to be gripped by the tongs.

In Fig. 14 is shown one way where this right-and-left coupling is used to the best advantage. *A* represents a steam or hot-water riser placed in a partition with its lower end extending down below the bottom of the joist in the cellar ceiling, as is done where pipes are concealed or plastered over, so that in such cases all risers

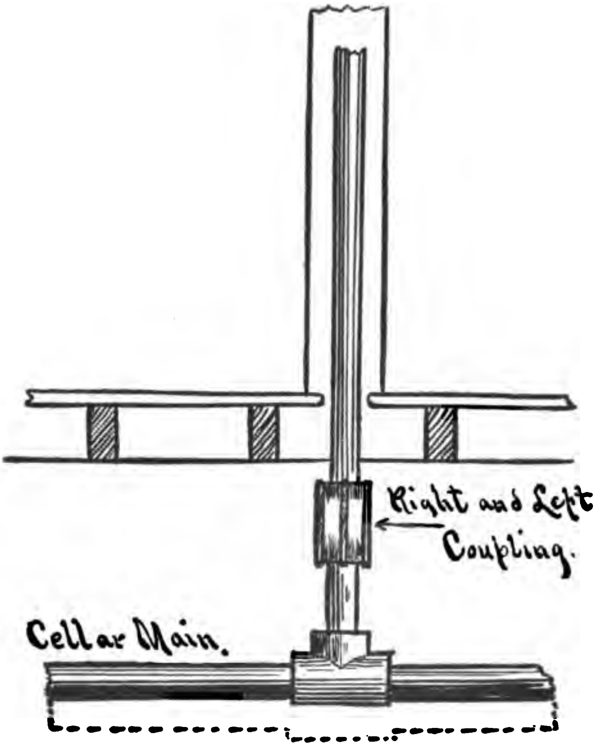

Fig. 14.

are put in place before any cellar work is done, and at the foot of all such risers it becomes necessary to make a union connection of some kind, and in any place where there is room to spring the pipe enough to enter or place the coupling between the two ends of the pipe to be connected. It is the best joint or connection, because it is then just the same as a regular coupling that comes on the end of each length of pipe.

But the secret of how to properly make this connection perfectly tight when screwed together is what puzzles the man or boy of little experience. And I would say that there is no trouble or bother about it, if you know the right way of doing it.

The dotted line, as may be noticed in Fig. 14, represents the cellar main, or whatever the pipe may be, loosened or sprung down to allow the coupling to be placed in between the ends of the pipes to be connected. This becomes necessary, because in such places, as a general rule, the upper pipe or riser is fixed solid or made stationary, so that all the movement will have to come from the bottom.

To make the right-and-left coupling perfectly tight on both ends when screwed up, there are just two things to be careful about. The first is, to be sure that the threads or the ends of the pipe are cut full and clean. And this applies also to any other kind of fitting. What I mean by a full and clean-cut thread is that the die should be allowed to run its full thickness on the pipe, so as to get the length of the thread on the pipe that the die is made to give it. Then be sure that the thread is not only full in length, but full in height; that is, it must have a real and complete thread, not part of one, as is the case where we have what is called a poorly-cut thread; that is, part of it torn or stripped off. Bad threads, as a rule, are caused by using a worn-out or partly broken die, sometimes by allowing the iron cuttings to clog the die, and very often by allowing the die to become hot from the want of oil or water, as the case may be. These are some of the fundamental principles, and there can be no proper thread connection made unless the threads are clean cut and full as they are intended to be.

The best oil to use for pipe-cutting is what is known in the market as machine oil, or lard oil will do very well. And I might state that it is very important to have the ends of the pipe squarely cut off to have the best kind of joint; it also enables us to make the connection with much less trouble. Now, as to the screwing of the right-and-left coupling together, having the threads all O K—not only on each end of the pipe to be connected, but in the coupling itself. It is very important to bring the two ends of the pipe in a perfect line with each other, and because this very important thing is not done, a large amount of time is often lost in trying to start the thread to make such connections. Having made sure that the pipes to be connected are in perfect line with each other, we begin to screw the coupling on one end of the pipe by the hands until it becomes as tight as we can turn it without the tongs or wrench; we then mark it or the side and also mark the pipe at the same position, and, after marking the coupling and the pipe, we unscrew the coupling from the pipe, and, while doing so, count the number of turns it requires to take it off Suppose this was the upper end, and the number of turns required to remove it was five and a half, we then screw the other end of the coupling on the lower end of the pipe in the same way with our hands, marking it in the same way; then turn it back, keeping count of the number of turns, and, supposing the bottom side came off by only four turns, there would be a difference of one and a half turns between the upper and lower ends of the coupling.

Now, we must be careful not to mix up the ends or forget which is the top and which is the bottom. The next thing to do is to start the upper end first, and, after having applied a little oil on the threads for the purpose of making it screw together with more ease (and I might say here that it makes a better joint than cement or red lead in such cases), we give the upper end of the coupling one and a half turns first, then bring the lower part pressed up tightly against the coupling, and then begin to screw the coupling on both the lower and upper ends of the pipe at the same time; now turn with the tongs or wrench until it feels tight, or, in some cases, until the coupling begins to feel warm. Do not be afraid of breaking anything in screwing up a steam or hot-water connection. Joints made in this way will never leak, and there will be no time lost in having to go over them the second time

CONNECTING RIGHT-AND-LEFT ELBOWS.

A right-and-left elbow is connected up in the same general way as that of the coupling. It not only makes the neatest and best kind of a job, but it makes it unnecessary to use an extra fitting in making the connection. There will be many places found in constructing a hot-

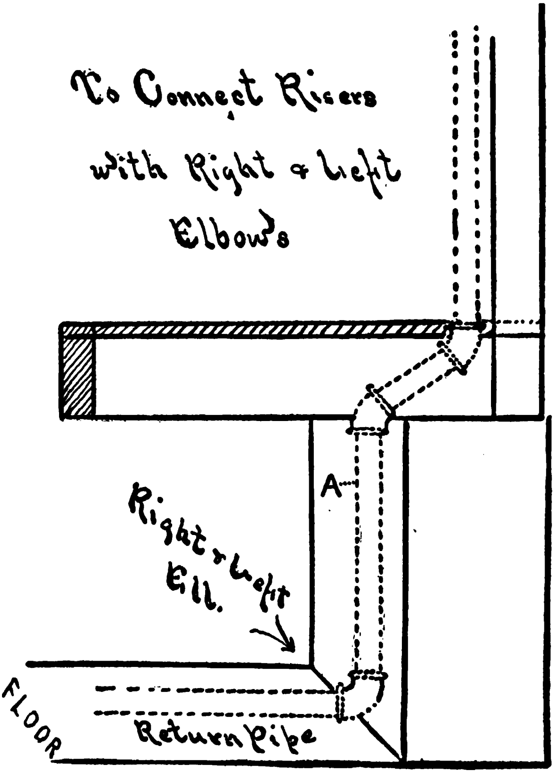

Fig. 15.

water or steam heating plant where the right-and-left elbows can be used, and one of the many places is shown in Fig. 15. In this plate *A* represents a riser or return pipe passing from some upper floor to the cellar floor.

The Long Screw
or Running Thread.

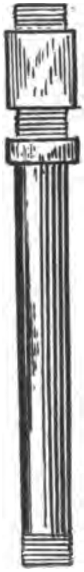

Fig. 16.

Where there is an offset in the wall, as shown in Fig. 15, it will be the best kind of a job to run this pipe as shown, using forty-five-degree ells. Using angle fittings of this kind in such places not only give the steam and water a chance to do their work much better than if they were run over the offset at an angle of ninety degrees, but it saves in the length of pipe, which might be considered. To make such a connection as shown in Fig. 15, we place the right-and-left elbow on the bottom near the floor, as shown, with the left-hand thread up; we then take the measure of the upright piece of pipe, as shown at *A*, allowing for a little clearance between the bottom of the pipe or elbow and the floor under it, so the horizontal return pipe, *P*, can be lowered enough to allow the two ends of the upright pipe to enter the ends of the fittings at the same time. We then do the very same thing with the upright piece of pipe as we did with the right-and-left coupling: first, screw it into one end by hand; then mark it and the fitting; after it is marked, unscrew again, keeping count of the number of turns or threads it went on; then do the same thing with the other end, continuing the operation as described for the coupling.

THE LONG SCREW OR RUNNING THREAD CONNECTION (Fig. 16).

This special fitting or connection is used quite often, and especially in places where the flange union has not room enough to be placed, or where it may not be wanted on account of its appearance, or in places where the fittings are already on both ends of the pipes to be connected, but which have only right-hand threads. The long screw is always made with right-hand threads only. This kind of connection has also another advantage, that of joining two pipes together, where they are both securely fastened, and cannot be raised or lowered, and at the same time making a perfect tight steam or hot-water job. The long screw consists of a nipple with a regular size or length thread on one end and an extra long thread on the other end, also a coupling and a part of a coupling or locknut.

In placing the running thread in a connection, we first screw the bottom or the regular length thread into its place, taking care that it is as long as possible, and yet passes in between the two pipes to be connected. After screwing down the first end, we will be short the length of the thread which has been screwed down into it, or that much from the top pipe to connect with. But the length of the coupling on the nipple makes up for that. And now, after applying a little oil or red lead to the threads on the upper end, we unscrew the coupling from its nipple, and screw it up tight on the upper end of the pipe to be connected. This leaves the lower end of the coupling loose after being unscrewed from the nipple, and this coupling will now be found to be more on the upper pipe than on the nipple from which it was unscrewed, and also leaves quite a space between itself and the half-coupling or locknut, which is also on the long-threaded nipple.

The next thing to do will be to get a little asbestos wicking, or regular cotton lamp wicking with a little oil or grease in it, and wind it around the threads of the nipple close to the coupling; then screw up the half-coupling or locknut against it as tight as it will go. This wicking or packing will make up for the loose-

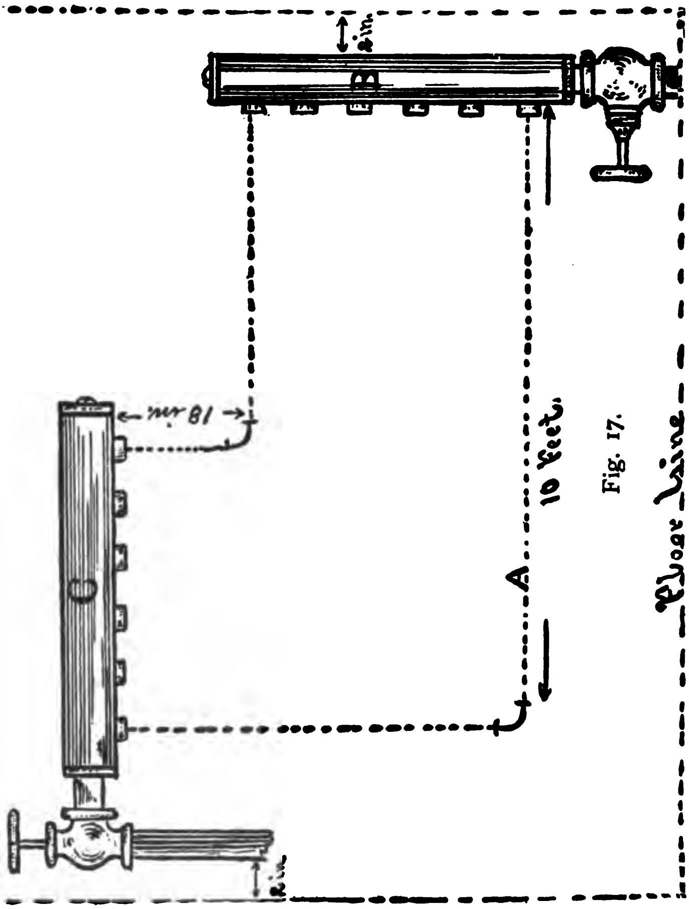

Fig. 17.

ness of the thread, and keep the connection from leaking.

WALL COILS FOR STEAM OR HOT-WATER HEATING—HOW TO PROPERLY MAKE COILS.

As a general thing coils are made as long as the room or wall space, where they are intended to be placed, will allow them to be. The first thing to do is to find out what this length is, and allow two or three inches of clearance on each end, as shown in Fig. 17, the dotted lines indicating the length of wall space where the coil is to be placed.

To make a manifold coil with upright expansion end, we lay out the room or distance of wall space for the coil on the shop floor, or in the building where the work is being done, when we have room enough to do so, and place a manifold at each end, as shown in Fig. 17. (For illustration we will make a six-pipe coil; it makes no special difference what number of pipes the coil may be made of, as the same principle applies to any number or size.) To make a neat looking or nicely proportioned expansion end of this style of coil, the shortest upright pipe is made about 18 inches long, as marked in sketch. Place the manifolds on the floor in the position they occupy when finished, in a complete coil, allowing about 2 inches on each end clear of everything, which allowance is made for the expansion and contraction of the coil itself. We now take the measure of the long or bottom pipe, marked *A*, and after making the proper allowance for the length of threads to screw in on both ends, we find that it would be 10 feet. We then add 18 inches more to it, which now makes it 11½ feet. So we cut out six pieces of pipe 11½ feet long each, taking care that each piece is properly straightened, and examined to be sure that there are no dirt-splits or flaws in them,—as pipe as small as 1 inch, 1¼ inches, and 1½ inches is used more than other sizes for coils, and such sizes get more or less bent in handling, also often get clogged with grease and dirt. After cutting out the six pieces, we lay them down on the floor, one end pushed up against a piece of board, which is nailed to the floor, as shown in Fig. 18.

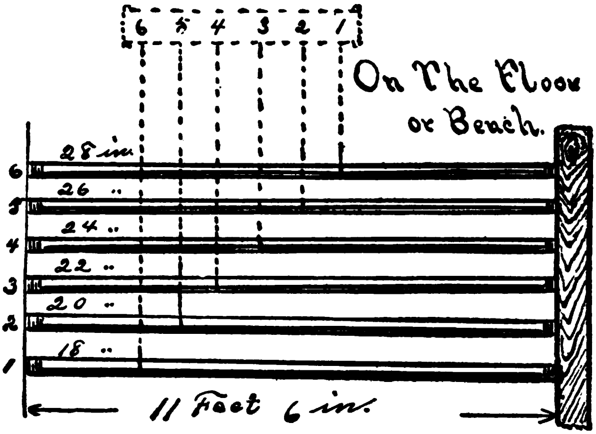

Fig. 18.

We now mark each pipe in number as shown on left-hand side of pipe, calling the bottom one No. 1, and so on up to the top, which is No. 6.

The next move to make is to measure off 18 inches, and if the distance from centre to centre of the outlets in the manifolds is 2 inches, we then mark off 20 inches on pipe No. 2, or whatever the distance of openings may be in the manifolds. Considering the distance in this case to be 2 inches, we make a difference of 2 inches in each length, so No. 3 is marked off 22 inches; No. 4, 24 inches; No. 5, 26 inches, and No. 6, 28 inches. These six pieces are now cut off as marked, then each end is properly threaded with the long or bottom pieces, all right-hand threads on both ends, right-and-left elbows screwed on tightly on one end, and the short or upright pieces, having right-hand threads on top, and left-hand threads cut on bottom, as shown and marked in Fig. 19.

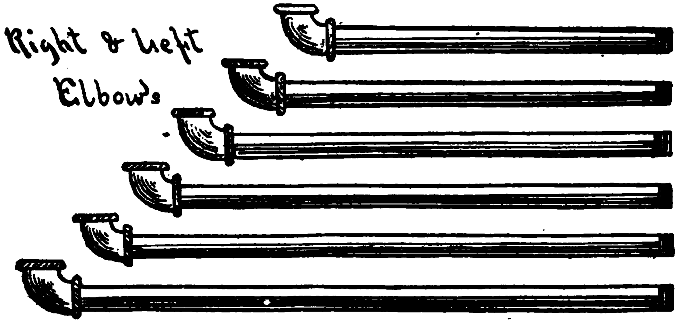

Fig. 19.

The next operation is to begin to screw up the long or bottom pipes into *their* manifold, *B*, beginning with the top one, or No. 6, so that it may be hung in on the hook plate. These bottom pipes being in their places, we next take the 18-inch piece, No. 1, which we cut from the bottom piece, as shown in Fig. 18, and connect it with manifold *C* and the upper horizontal pipe. As it is the shortest piece, it fills the shortest place, and the connecting of these pieces to the right-and-left elbow is done as described under the head of making right-and-left connections. Piece No. 2 comes next, as it is the next shortest, and connected to the second pipe from the top. So that the piece cut from the top pipe in the beginning fits and is connected to the bottom pipe in the complete coil. Now we have the complete

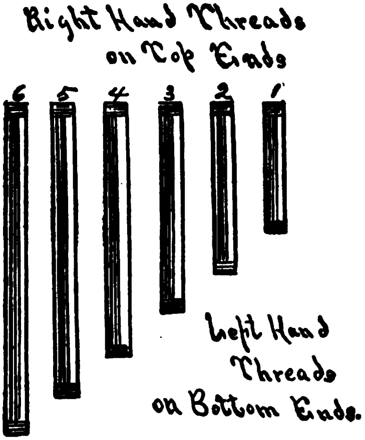
Right Hand Threads on Top Ends
6
5
4
3
2
1
Left Hand Threads on Bottom Ends.

Fig. 20.

manifold wall coil, with upright expansion end, as shown in Fig. 21.

Where coils of this make are very long, the expansion end would have to be higher, according to the length of the coil, to make provision for the extra expansion, which might be considered to move about 1⅜ inches in 100 feet in a change of temperature from 30° to 212°, or about one nine-hundredths of its length. This must be considered in the running of hot-water or steam pipes of any kind.

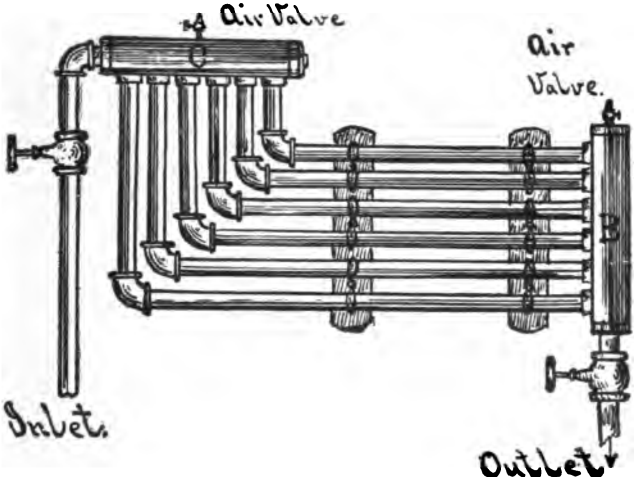

Fig. 21.

It is an easy matter where this style coil is used to give it plenty of fall or pitch, as the flow of water or steam, as the case may be, in it runs all in the same direction, and that is toward the outlet; and the more fall we give the coil, the better it will heat, or the more easy the circulation will be through it. In the coil at the upper end of manifold *B* we place an air valve to allow the air to escape, if it is used for steam; and if the same coil is used for hot water, we place the air valve on the top of manifold *C*, as shown in Fig. 21,

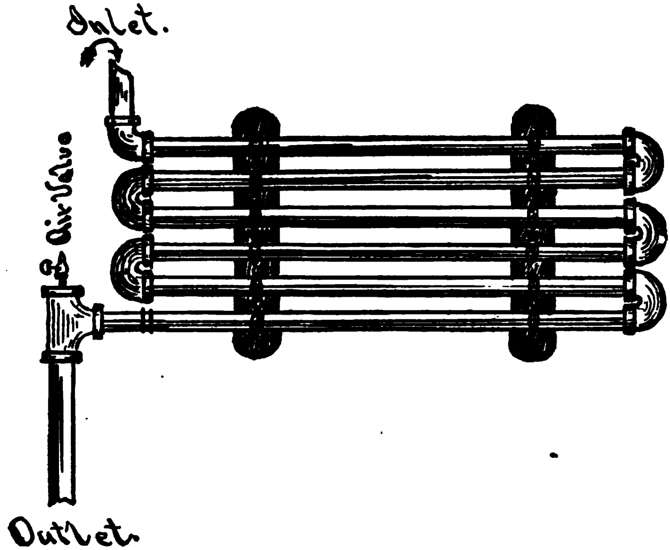

Fig. 22.

and the inlet to be at the highest point, as shown, and outlet at the lowest, for either steam or hot-water heating.

THE RETURN-BEND COIL.

Another make or style of coil is the coil made by the use of return bends, and is shown in Fig. 22.

This style coil will do very well for short lengths, but is not a good heating coil for long lengths, as it is simply a continuation of a single pipe; and as it cannot have very much pitch or fall, it will not be very good for the circulation of either water or steam through it. In making this style coil the lengths of pipe, with the fittings properly screwed on, are prepared as shown in Fig. 23.

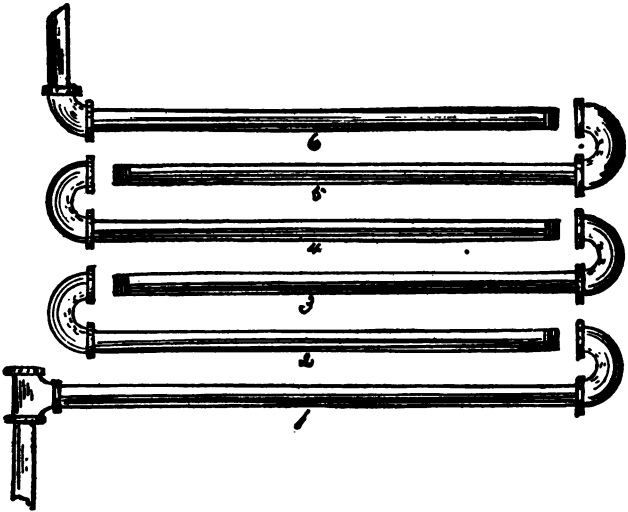

Fig. 23.

Beginning at the bottom, rest No. 1 on its hook plate or any other support. Then screw Nos. 2, 3, 4, 5, and 6, in their turns, until finished, as shown in Fig. 22; When this style coil is used for steam heating, we place an air valve on the outlet end, as shown in Fig. 22, *Air Valve;* but when the sam ekind of coil is used for hot-water heating, we must provide for the escapement of the air out through the highest point of the pipe, or above the inlet.

THE DOUBLE RETURN-BEND COIL.

Another form of coil where the return bend is used is shown in Fig. 24.

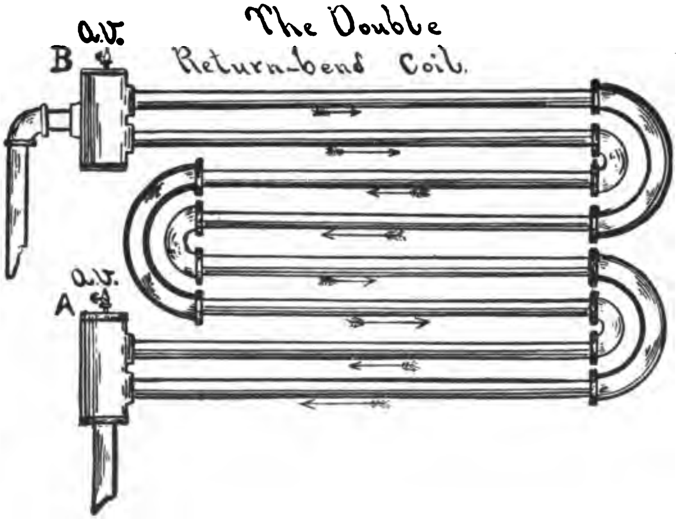

Fig. 24.

This is a great improvement over the coil just described in Fig. 23. As will be noticed, it is a continuation of two pipes in place of one. Two pipes are supplied by one connection in this case, where only one was supplied in the other, and at the same time being the same distance apart, or, in other words, resting on the same size hook plates. The direction of circulation through this coil is shown by the direction of the arrows. When this style of coil is used for steam heating, it will

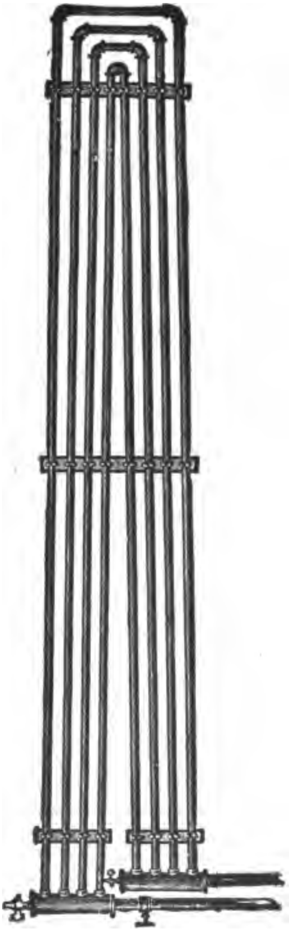

Fig. 25.

be a good plan to place an air valve on the return connection, as shown at *A;* and when used for hot-water heating, the air valve is to be placed at *B*, on the top of the inlet connection. This style return-bend coil is much better for hot-water work than the single return-bend or single connection; and I would always recommend its use in preference to the other for good results in heating. This general principle of constructing wall coils, having the supply and return at the same end, may be carried out for any number of pipes by simply using the regular manifolds on one end, and right-and-left elbows on the other end, as shown in Fig. 25.

This arrangement of the pipes always provides for expansion, and is good for either steam or hot-water heating—bearing in mind, as stated before, to use the upper air valve for hot water and the lower one for steam heating.

WROUGHT-IRON STEAM, GAS, AND WATER PIPE.

It will be necessary for the fitter at times to know the different sizes of pipes, their capacities, and in fact everything about them; but not all the different things at the same time. It may happen that at one time we only want to know the outside diameter of a pipe, and for this purpose alone we will have a special table of outside diameters; so it will save time and often mistakes which are caused by having too many figures squeezed together. And often the wrong line of figures is taken for the one we want. So in preparing the tables of such matter the object will be to keep everything separate, with a heading in each case for itself; as the more simple and plain anything can be made, the more good will always come from it. Our first list will be the outside diameter of the standard sizes of wrought-iron pipe.

The sizes of pipe in this list, from 1/8 to 10 inches, are the sizes of the inside diameters, as called; but the actual inside diameters vary a little from their so-called sizes.

OUTSIDE DIAMETER OF STANDARD WROUGHT-IRON STEAM, GAS AND WATER PIPE, FROM ⅛ TO 10 INCHES.

Size of Pipe......................	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside Diameter of Pipe........	$\frac{40}{100}$	$\frac{54}{100}$	$\frac{67}{100}$	$\frac{84}{100}$	$1\frac{5}{100}$
Size of Pipe......................	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside Diameter of Pipe........	$1\frac{31}{100}$	$1\frac{66}{100}$	$1\frac{90}{100}$	$2\frac{37}{100}$	$2\frac{87}{100}$
Size of Pipe......................	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside Diameter of Pipe........	$3\frac{50}{100}$	$4\frac{00}{100}$	$4\frac{50}{100}$	$5\frac{00}{100}$	$5\frac{56}{100}$
Size of Pipe......................	6	7	8	9	10
Outside Diameter of Pipe........	$6\frac{62}{100}$	$7\frac{62}{100}$	$8\frac{62}{100}$	$9\frac{68}{100}$	$10\frac{77}{100}$

THICKNESS OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM $\frac{1}{8}$ TO 10 INCHES.

Size of Pipe....................	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Thickness of Pipe	$\frac{68}{1000}$	$\frac{88}{1000}$	$\frac{91}{1000}$	$\frac{109}{1000}$	$\frac{113}{1000}$
Size of Pipe....................	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Thickness of Pipe	$\frac{134}{1000}$	$\frac{140}{1000}$	$\frac{145}{1000}$	$\frac{154}{1000}$	$\frac{204}{1000}$
Size of Pipe....................	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Thickness of Pipe	$\frac{217}{1000}$	$\frac{226}{1000}$	$\frac{237}{1000}$	$\frac{247}{1000}$	$\frac{259}{1000}$
Size of Pipe....................	6	7	8	9	10
Thickness of Pipe	$\frac{280}{1000}$	$\frac{301}{1000}$	$\frac{322}{1000}$	$\frac{344}{1000}$	$\frac{366}{1000}$

INSIDE CIRCUMFERENCE OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM ⅛ TO 10 INCHES.

Size of Pipe in Inches............	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Inside Circumference of Pipe in Inches........................	$\frac{884}{1000}$	$1\frac{44}{1000}$	$1\frac{552}{1000}$	$1\frac{957}{1000}$	$2\frac{589}{1000}$
Size of Pipe in Inches............	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Inside Circumference of Pipe in Inches........................	$3\frac{292}{1000}$	$4\frac{335}{1000}$	$5\frac{61}{1000}$	$6\frac{494}{1000}$	$7\frac{754}{1000}$
Size of Pipe in Inches............	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Inside Circumference of Pipe in Inches........................	$9\frac{636}{1000}$	$11\frac{136}{1000}$	$12\frac{648}{1000}$	$14\frac{253}{1000}$	$15\frac{849}{1000}$
Size of Pipe in Inches............	6	7	8	9	10
Inside Circumference of Pipe in Inches........................	$19\frac{54}{1000}$	$22\frac{68}{1000}$	$25\frac{76}{1000}$	$28\frac{277}{1000}$	$32\frac{475}{1000}$

OUTSIDE CIRCUMFERENCE OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM 1/8 TO 10 INCHES.

Size of Pipe in Inches...........	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside Circumference...........	$1\frac{272}{1000}$	$1\frac{696}{1000}$	$2\frac{221}{1000}$	$2\frac{652}{1000}$	$3\frac{299}{1000}$
Size of Pipe in Inches............	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside Circumference	$4\frac{834}{1000}$	$5\frac{225}{1000}$	$5\frac{969}{1000}$	$7\frac{461}{1000}$	$9\frac{32}{1000}$
Size of Pipe in Inches............	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside Circumference...........	$10\frac{996}{1000}$	$12\frac{566}{1000}$	$14\frac{237}{1000}$	$15\frac{708}{1000}$	$17\frac{475}{1000}$
Size of Pipe in Inches............	6	7	8	9	10
Outside Circumference...........	$20\frac{818}{1000}$	$23\frac{954}{1000}$	$27\frac{96}{1000}$	$30\frac{488}{1000}$	$33\frac{772}{1000}$

LENGTH OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE CONTAINING ONE SQUARE FOOT OF OUTSIDE SURFACE, FROM 1/8 TO 10 INCHES.

Size of Pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Feet of Pipe containing one square foot of outside surface	$9\frac{440}{1000}$	$7\frac{75}{1000}$	$5\frac{657}{1000}$	$4\frac{322}{1000}$	$3\frac{697}{1000}$
Size of Pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Feet of Pipe containing one square foot of outside surface	$2\frac{903}{1000}$	$2\frac{302}{1000}$	$2\frac{00}{1000}$	$1\frac{602}{1000}$	$1\frac{328}{1000}$
Size of Pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Feet of Pipe containing one square foot of outside surface	$1\frac{91}{1000}$	$\frac{955}{1000}$	$\frac{849}{1000}$	$\frac{765}{1000}$	$\frac{629}{1000}$
Size of Pipe	6	7	8	9	10
Feet of Pipe containing one square foot of outside surface	$\frac{577}{1000}$	$\frac{505}{1000}$	$\frac{444}{1000}$	$\frac{394}{1000}$	$\frac{355}{1000}$

LENGTH OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE CONTAINING ONE SQUARE FOOT OF INSIDE SURFACE, FROM $\frac{1}{8}$ TO 10 INCHES.

Size of Pipe....................	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Feet of Pipe in one square foot of inside surface.................	$14\frac{150}{1000}$	$10\frac{500}{1000}$	$7\frac{670}{1000}$	$6\frac{180}{1000}$	$4\frac{635}{1000}$
Size of Pipe.....................	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Feet of Pipe in one square foot of inside surface.................	$3\frac{679}{1000}$	$2\frac{768}{1000}$	$2\frac{371}{1000}$	$1\frac{848}{1000}$	$1\frac{547}{1000}$
Size of Pipe.....................	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Feet of Pipe in one square foot of inside surface.................	$1\frac{245}{1000}$	$1\frac{77}{1000}$	$\frac{949}{1000}$	$\frac{848}{1000}$	$\frac{757}{1000}$
Size of Pipe.....................	6	7	8	9	10
Feet of Pipe in one square foot of inside surface........	$\frac{630}{1000}$	$\frac{544}{1000}$	$\frac{478}{1000}$	$\frac{425}{1000}$	$\frac{381}{1000}$

OUTSIDE AREA OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM 1/8 TO 10 INCHES.

Size of Pipe in Inches............	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside Area of Pipe in Inches ...	$\frac{129}{1000}$	$\frac{229}{1000}$	$\frac{358}{1000}$	$\frac{554}{1000}$	$\frac{866}{1000}$
Size of Pipe in Inches............	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside Area of Pipe in Inches ...	$1\frac{357}{1000}$	$3\frac{164}{1000}$	$3\frac{835}{1000}$	$4\frac{430}{1000}$	$6\frac{491}{1000}$
Size of Pipe in Inches............	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside Area of Pipe in Inches ...	$9\frac{62}{1000}$	$12\frac{566}{1000}$	$15\frac{904}{1000}$	$19\frac{635}{1000}$	$24\frac{299}{1000}$
Size of Pipe in Inches............	6	7	8	9	10
Outside Area of Pipe in Inches ...	$34\frac{471}{1000}$	$45\frac{663}{1000}$	$48\frac{426}{1000}$	$73\frac{715}{1000}$	$90\frac{792}{1000}$

INSIDE AREA OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM ⅛ TO 10 INCHES.

Size of Pipe in Inches.......	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Inside Area of Pipe in Inches	$\frac{578}{100000}$	$\frac{1041}{100000}$	$\frac{1916}{100000}$	$\frac{3048}{100000}$	$\frac{5333}{100000}$
Size of Pipe in Inches.......	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Inside Area of Pipe in Inches	$\frac{8627}{10000}$	$1\frac{4960}{10000}$	$2\frac{380}{100000}$	$3\frac{3550}{10000}$	$4\frac{7880}{10000}$
Size of Pipe in Inches.......	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Inside Area of Pipe in Inches	$7\frac{3880}{10000}$	$9\frac{8870}{10000}$	$12\frac{7300}{10000}$	$15\frac{9390}{10000}$	$19\frac{9900}{10000}$
Size of Pipe in Inches.......	6	7	8	9	10
Inside Area of Pipe in Inches	$28\frac{8990}{10000}$	$38\frac{7370}{10000}$	$50\frac{320}{100000}$	$63\frac{6880}{10000}$	$78\frac{8380}{10000}$

LENGTH OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE THAT WILL HOLD ONE CUBIC FOOT OF WATER, FROM 1/8 TO 10 INCHES.

Size of Pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Feet of Pipe containing One Cubic Foot of Water................	2500	1385	$751\frac{50}{100}$	$472\frac{40}{100}$	270
Size of Pipe..................	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Feet of Pipe containing One Cubic Foot of Water................	$166\frac{90}{100}$	$96\frac{25}{100}$	$70\frac{65}{100}$	$42\frac{36}{100}$	$30\frac{11}{100}$
Size of Pipe.....................	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Feet of Pipe containing One Cubic Foot of Water................	$19\frac{49}{100}$	$14\frac{56}{100}$	$11\frac{31}{100}$	$9\frac{3}{100}$	$7\frac{20}{100}$
Size of Pipe.....................	6	7	8	9	10
Feet of Pipe containing One Cubic Foot of Water................	$4\frac{98}{100}$	$3\frac{72}{100}$	$2\frac{88}{100}$	$2\frac{26}{100}$	$1\frac{80}{100}$

WEIGHT OF WATER IN LBS. CONTAINED IN ONE FOOT OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM ¾ TO 16 INCHES.

Size of Pipe	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
Weight of Water in One Foot in Length	$\frac{25}{100}$	$\frac{37}{100}$	$\frac{64}{100}$	$\frac{88}{100}$	$1\frac{45}{100}$

Size of Pipe	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$
Weight of Water in One Foot in Length	$2\frac{7}{100}$	$3\frac{20}{100}$	$4\frac{28}{100}$	$5\frac{50}{100}$	$6\frac{92}{100}$

Size of Pipe	5	6	7	8	9	10
Weight of Water in One Foot in Length	$8\frac{68}{100}$	$12\frac{25}{100}$	$16\frac{87}{100}$	$21\frac{61}{100}$	$27\frac{25}{100}$	$34\frac{50}{100}$

Size of Pipe	11	12	13	14	15	16
Weight of Water in One Foot in Length	$41\frac{50}{100}$	49	$59\frac{85}{100}$	$68\frac{93}{100}$	$82\frac{20}{100}$	$91\frac{70}{100}$

WEIGHT PER FOOT IN LENGTH OF STANDARD SIZE WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM $\frac{1}{8}$ TO 10 INCHES.

Size of Pipe....................	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Weight per Foot in Length in lbs.	$\frac{243}{1000}$	$\frac{422}{1000}$	$\frac{561}{1000}$	$\frac{845}{1000}$	$1\frac{126}{1000}$
Size of Pipe....................	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Weight per Foot in Length in lbs.	$1\frac{670}{1000}$	$2\frac{258}{1000}$	$2\frac{694}{1000}$	$3\frac{667}{1000}$	$5\frac{773}{1000}$
Size of Pipe....................	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Weight per Foot in Length in lbs.	$7\frac{547}{1000}$	$9\frac{55}{1000}$	$10\frac{728}{1000}$	$12\frac{492}{1000}$	$14\frac{564}{1000}$
Size of Pipe....................	6	7	8	9	10
Weight per Foot in Length in lbs.	$18\frac{767}{1000}$	$23\frac{410}{1000}$	$28\frac{348}{1000}$	$34\frac{677}{1000}$	$40\frac{641}{1000}$

NUMBER OF THREADS TO THE INCH OF SCREW ON STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE, FROM ⅛ TO 10 INCHES.

Size of Pipe....................	⅛	¼	⅜	½	¾
Number of Threads per Inch	27	18	18	14	14
Size of Pipe....................	1	1¼	1½	2	2½
Number of Threads per Inch	11½	11½	11½	11½	8
Size of Pipe....................	3	3½	4	4½	5
Number of Threads per Inch	8	8	8	8	8
Size of Pipe....................	6	7	8	9	10
Number of Threads per Inch.....	8	8	8	8	8

It will be noticed in the above table that the ⅛-inch pipe is the small size alone; ¼-inch and ⅜-inch are the next sizes; then come two more, ½-inch and ¾-inch, which are third in size; the fourth size takes in from 1-inch to 2-inch pipe; from 2-inch pipe up, on all other sizes, we have the largest thread, or 8 threads to the inch.

TEMPERATURE OF STEAM IN STEAM PIPES WHERE THERE IS A PERFECT CIRCULATION UNDER DIFFERENT PRESSURES.

Pounds Pressure per Square Inch.	*Temperature in Fahrenheit Degrees.*
5	227.917
10	240.100
15	250.245
20	259.176
25	267.120
30	274.296
35	280.854
40	286.897
45	292.520
50	297.777
55	302.718
60	207.388
65	311.812
70	316.021
75	320.039
80	323.884
85	327.571
90	331.113
95	334.523
100	337.814
105	340.995
110	344.074
115	347.059
125	352.757
135	358.161
145	363.277
155	368.158
165	372.822
175	377.281
185	381.573
235	401.072
285	418.225
335	431.956
385	444.919

THE EXPANSION IN LENGTH OF WROUGHT-IRON STEAM AND WATER PIPES.

To closely calculate on the amount of expansion and contraction in length of steam and hot-water pipes, with different temperatures, for ordinary practice in fitting up a heating plant, we will take, for example, a pipe 100 feet long, containing cold water, or without either steam or water, and being at a temperature of about 32 degrees Fahrenheit, which it might be before starting a fire in the heater. After starting the fire and heating the water in the pipe up to 215 degrees, or 1 pound pressure of steam, we would find the pipe to be 100 feet 1½ inches long. In a rise in temperature from 32 degrees to 265 degrees, or 25 pounds pressure of steam, we would have an increase in length of 1$\frac{8}{10}$ inches. From 32 degrees to 297 degrees, or 50 pounds steam pressure, the increase would be 2$\frac{1}{10}$ inches. And again, a rise in temperature from 32 degrees to 338 degrees, or 100 pounds pressure of steam, and we will have an increase in length of 2½ inches.

This will be close enough for practical work, and is within the one-hundredth part of an inch.

TABLE OF THE EXPANSION OF WATER AT DIFFERENT TEMPERATURES.

Temperature of Water in Degrees Fahrenheit.	*We will take Forty Degrees as a basis to figure from.*
40	1.000
50	1.00025
60	1.00090
70	1.00190
80	1.00324
90	1.00489
100	1.00682
110	1.00903
120	1.01144
130	1.01409
140	1.01696
150	1.02002
160	1.03326
170	1.02667
180	1.03024
190	1.03396
200	1.03781
210	1.04180
212	1.04262

A cubic foot of water at 40 degrees temperature weighs about 62½ pounds, and should this amount of water be placed in a vessel so that it exactly filled it, and then heat applied under this vessel so as to heat the water, and the water's temperature made to rise to 212 degrees Fahrenheit, the water would overflow the vessel and 2½ pounds of the water would escape; so that the cubic foot of water at 212 degrees, or the boiling-point in an open vessel, would only weigh about 60 pounds. This will come in handy for any person who may want to find out the necessary size of an expansion tank for any job.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 434. For ordinary calculation in practice we consider that, for every foot in height of water in a pipe, it will give a half-pound pressure per square inch.

RADIATING SURFACE.

Having passed over the tables of sizes and capacities of pipes in various ways, we will now consider the amount of radiating surface necessary to properly heat a room of a given size to about 70 degrees in zero weather, as required in a heating plant for domestic heating purposes. The exact amount of radiating surface necessary to heat a given amount of cubic feet of air, or a given size room, to 70 degrees or any other number of degrees, in all kinds of temperature of the outside atmosphere, and for the different kinds of buildings, is something that has never been figured out by any one, and it never will be. Therefore we will have to do some guessing in regard to that matter; and the man having the largest practical experience can always make the best guess. So the best that any one can do is to use the best judgment according to his experience, or follow as near as he can the principles of some reliable experienced mechanic. There will be found very many different situations in regard to the rooms to be heated, and in regard to the situation of the house itself; also the different materials the house or building to be heated is made of, the number of windows and doors, and whether the room is a centre room, protected on every side, or whether it is exposed on every side; whether it is located on the north or south side of the house, or whether it is on the first, second, third, fourth, or any other floor.

All these things and as many more are to be considered in order to get as near as possible to the proper amount of radiating surface, so that the job may be done properly and at the same time in an economical way. That is, it would not be difficult to find out what amount of radiating surface would be necessary to properly heat the coldest or most exposed room, or the amount necessary to heat the most protected room; and it would not do to use the amount of radiating surface necessary for the coldest room in the room most protected; that would be extravagant and unnecessary. Therefore, to properly proportion the amount of radiating surface necessary for every room is a matter that we must use our best judgment on. As I said before, there is nothing so good as experience for this part of the work. There are no tables that will tell us this. We have a table which gives us an idea as to the amount of surface generally placed, and this table means, and it is understood, that when it says one square foot of radiating surface will heat so many cubic feet of air space on a first, second, or any other floor, it will do this if the water in the radiator is at a temperature of from 180 degrees to 205 degrees; or in the case of steam, if low pressure, it means that the radiator must be filled with steam at a pressure of about 5 pounds per square inch. Therefore, if these points are carried out, using the amount of radiating surface called for in this list, which is based on experience, we will come close enough to the proper amount necessary in the average heating plants for domestic purposes.

APPROXIMATE PROPORTIONS OF RADIATING SURFACE TO CUBIC CAPACITIES OF SPACE TO BE HEATED.

ONE SQUARE FOOT OF RADIATING SURFACE WILL HEAT	IN DWELLINGS, SCHOOL-ROOMS, AND OFFICES.	IN HALLS, LOFTS, STORES, AND FACTORIES.	IN CHURCHES AND LARGE AUDITORIUMS.
With open tank or low-pressure direct hot-water radiating surface...	30 to 50 cubic feet of air.	60 to 80 cubic feet of air.	90 to 150 cubic feet of air.
With low pressure indirect hot-water radiation.	15 to 35 cubic feet of air.	20 to 45 cubic feet of air.	60 to 100 cubic feet of air.

APPROXIMATE PROPORTIONS OF RADIATING SURFACE TO CUBIC CAPACITIES OF SPACE TO BE HEATED.

ONE SQUARE FOOT OF RADIATING SURFACE WILL HEAT	IN DWELLINGS, SCHOOL-ROOMS, AND OFFICES.	IN HALLS, LOFTS, STORES, AND FACTORIES.	IN CHURCHES AND LARGE AUDITORIUMS.
With low-pressure steam or high-pressure hot water direct radiating surface	50 to 80 cubic feet of air.	70 to 100 cubic feet of air.	160 to 250 cubic feet of air.
By indirect radiation	40 to 50 cubic feet of air.	55 to 75 cubic feet of air.	100 to 150 cubic feet of air.

TABLE SHOWING POWERS OF DIFFERENT SUBSTANCES FOR TRANSMITTING HEAT.

Window glass	1000
Oak or walnut	60
White pine	80
Pitch pine	100
Lath and plaster	75 to 100
Bricks (rough)	200 to 250
" (whitewashed)	200
Granite or slate	250
Sheet-iron	1030 to 1110

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By referring to the table of the "Power of Substances for Transmitting Heat" we can form some idea as to the different amounts of radiating surface necessary where such materials are used in the construction of a building. And having considered the amount of radiating surface to heat a given size room, based on the low-pressure list, we will also be able to see, by referring to the table of temperatures due to pressure, how much less radiating surface would do the work under a higher temperature.

In general practice, for an ordinary dwelling house where we heat with hot water, if the house is a good frame house, having sheathing boards and weather paper,—with siding on the outside and lath and plaster on the inside of the house,—we would consider that, for direct radiation on the first floor, one foot of radiating surface to 30 cubic feet of air space would be sufficient; and on the second floor, one foot of radiating surface to 45 cubic feet of air space. If there are three floors in such a house, we would consider that one foot of direct radiating surface to 60 cubic feet of air space would answer.

In figuring the cubic contents of rooms for this purpose, we must also take into consideration the height of the room. That is, a room having a very high ceiling would not require as much radiating surface per foot of its cubic contents as a room having the same cubical contents, but the ceiling of which was less in height, no matter what floor of the house or building the room may be on.

Sometimes, to make a rough and quick estimate on the amount of radiating surface necessary to heat a house, if it is all to be direct surface, we take the entire size of the house to be heated, both first and second floors, and figure up the cubic contents and divide it by 35, and in some cases by 40. If we want a hurried figure on the entire plant of an ordinary sized hot-water job, we know by experience that it can be done for one dollar per foot of direct radiating surface used. But that is not a proper way, nor a safe way, to do figuring. Some men will give a figure in this way to show how much they know, and how well they are posted; but the safest way for both the fitter and his customer is to thoroughly understand and know exactly what is required, having correct measurements of each room, on a plan showing their position and exposure, and from this same plan he can take the measurements of all his pipes close enough to figure from. Should he make this plan himself, by the time he has it made, and the measurements of his pipes and number and sizes of his fittings and valves, he will have a very good idea as to how long it will take to do the work, which must be guessed at in any case. By having a proper plan of our work as it is to be done, we often see great obstacles which must be provided for that we would never think of figuring on had we no *A* plan to go by. And again, no matter how well a man may know his business in these lines, I would advise him in all cases to have a plan of his work before he begins.

THE DIFFERENT KINDS OF RADIATING SURFACE.

We have considered to some extent the matter of direct radiating surface. Direct radiating surface means radiators, coils, or any kind of heating surface that is placed directly in the room or place to be heated, having no air flues of any kind connected with it for the purpose of ventilation.

DIRECT INDIRECT RADIATION.

Direct indirect or semi-direct radiation means radiators that are placed directly in the room or space to be heated. By this system a good ventilation of fresh air for the room is procured with much less expense than the all indirect system, as the fresh air is brought in from the outside atmosphere through the wall, directly behind. This style radiator is placed a little below the floor, making the channel quite short in distance. The radiator having its base closed on bottom ends and in front, the air must pass up from behind it, and in this way comes into the room heated to the proper temperature. To figure on the necessary amount of this kind of radiating surface to heat a room, we will add 25 per cent. more surface to that of the list for regular direct radiation.

INDIRECT RADIATION.

Indirect radiation means radiators that are placed in the basement or cellar of the house, or in any place other than the room they are to heat. As a rule they are placed in the cellar, where they are boxed up, having a channel or air pipe brought into them from outdoors, and a tin hot-air flue to carry the heated air from each nest to the room to be heated.

FLOOR PLAN OF A CHURCH TO BE HEATED BY DIRECT RADIATION—LOCATION OF THE RADIATORS—THE RADIATING SURFACE PROPERLY DIVIDED UP—PROPORTIONING PIPES FOR THE AMOUNT OF RADIATING SURFACE—THE EXPANSION OF LONG RUNS OF PIPE PROVIDED FOR.

We will next proceed to lay out the work for the heating of a church by direct hot-water radiation; a floor plan, which is shown in Fig. 26, and the kind of radiation to be used being fixed.

The next thing to consider is the size of the building. Presuming it to be 50 feet wide by 80 feet long, and on an average 46 feet high, this space figured up will be found to be 183,750 cubic feet. Our next matter will be to decide on what proportion of radiating surface we will allow per cubic foot of space; and this is where the guessing work comes in. We will have to consider the construction of the building—whether it is made of wood, brick, or stone; the number and size of windows, also the way windows are fitted, whether poorly fitted and loose, or well fitted and practically air tight when closed; and, if the building is a frame structure, whether it has sheathing boards and weather paper, as well as the finished siding, or whether it has only siding alone; also whether the building is plastered or not, and also the number and size of openings that may be in the ceiling for ventilation. These matters being all settled on, and we find it to be a good brick building, well plastered and the doors and windows properly fitted, the windows the average size and number as found in such buildings, we conclude that one square foot of direct hot-water radiating surface to 175 cubic feet of air space will properly heat this building.

Having figured the cubic contents and divided it by 175, we find it amounts to 1,050 feet of radiating surface. We will now have to fix on the location and number of radiators. As is usually the case, we place them, where there is an opportunity to do so, under the windows, as shown in Fig. 26; and to come as near as we can to having a uniform heat throughout the building, we must use some judgment in regard to where the radiators may be located as well as for the appearance. Having concluded how many radiators we intend to use, we will have to divide the 1,050 feet by that number, which in this case, as shown in Fig. 26, is 13.

The vestibule or entrance to the church being a cold place, as the doors are opened so much, it is a good plan to place plenty of surface in that part of the church. As will be noticed, the two radiators in the vestibule contain 125 feet of surface each, while those on each side of the auditorium contain only 75 feet

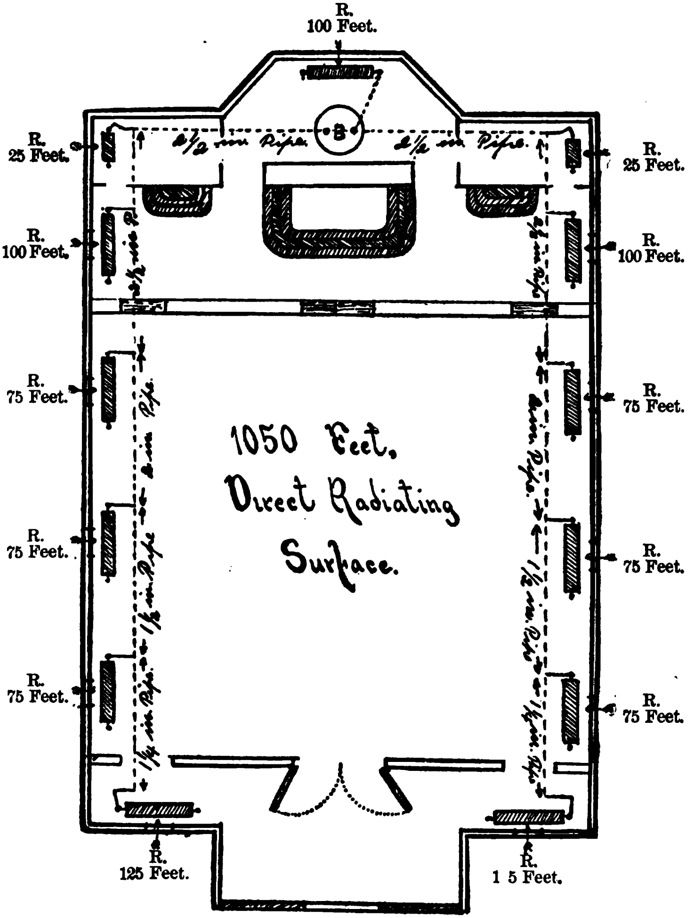

Fig. 26.

each; one in each vestry containing 25 feet of surface each, and one in the rear and on each side of the sanctuary containing 100 feet each. This disposes of the amount of radiating surface, and also places it where it will do the most good, to the best of our knowledge.

In the plan, Fig. 26, the radiators are indicated by *R*, also the number of feet each contain; the boiler being located under the sanctuary, as shown at *B*. We will next consider the size of the pipes and connections.

THE SIZE OF THE PIPES.

The most simple way, and the quickest, to get the size, is to begin at the extreme end of the line, or last radiator; and in this case, referring to Fig. 26, the extreme end or last radiator, or, in other words, the radiator which is the longest distance from the boiler, would be the radiator in the vestibule near the entrance to the church. The church being quite wide, 50 feet, it will be the best plan to run a separate pipe on each side, as shown in plan.

One taken off each side of the boiler, as shown, would be the best, as, by rising two or three feet from top of boiler, it would make a good expansion end for each line; while if we had only one connection on the boiler, and use a tee for the run on each side, we would not have the benefit of the loose end. And, besides, with the two-pipe connection we will not have to use such a large size piece of pipe, which for the average fitter is some bother in getting it cut and threaded. Having settled on running two lines from the boiler, we will now proceed to fix on the size of each piece of pipe; and as the furthest radiator on the line contains 125 feet of surface, we simply refer to a radiator list of any standard make, and we will find that this size is taken for 1¼-inch pipe, which is considered large enough. Therefore the pipes from this radiator to the next one on the same line will be 1¼-inch, as marked on the plan. As we will now have to supply two with the next piece of main pipe, and the next radiator, which only contains 75 feet of surface, is also tapped for 1¼-inch pipe, therefore we will make the next piece 1½-inch, as marked. Coming on back to the boiler, we have the third radiator, which also contains 75 feet of surface, and is tapped for 1¼-inch pipe; and the distance between these radiators being about 15 feet, it would be well to increase the size on the main again. As we have no size between 1½ and 2 inches, we will have to take 2-inch for the next piece of pipe. Now we put on another radiator which contains 75 feet of surface, and we make the next piece 2½-inch, as we have no 2¼-inch size. Then comes the fifth radiator from the end, or the second one from the boiler, which contains 100 feet of surface, but has only a 1¼-inch tapping, and we find that the 2½-inch pipe is still large enough for this and the 25-foot radiator also.

We continue this 2½-inch pipe to the boiler. The radiator located in the rear of the sanctuary will be supplied from a separate branch taken from the boiler, making it an independent line in itself. It will be noticed that the 2½-inch main line starting from the boiler supplies 475 feet of direct surface, having 125 feet of it about 80 feet away from the boiler; and with a gradual rise in the flow pipe from the boiler to the furthest end of it of about 15 inches, it will work to perfection. The other side of the church is exactly the same as described.

In a case of this kind, where we have several branches taken off a long line of flow pipe, it is well to locate the main flow pipe some distance away from the side wall, as shown in Fig. 26. This is done for the purpose of allowing the main pipe to move freely, which it could not do if the connections to the risers were short or close, and in this way make the expansion and contraction easy. This branch should not be less than about 2 feet, and always more, if possible. At both ends of the long line we turn off with two or three bends, in place of going more direct to the radiators. This is always done for the purpose of allowing for the expansion. This matter should be looked to more especially where large size pipes are used, as they will not bend so easily, and should their ends be connected in a solid way without allowing for the expansion, something would have to break. The return pipe should be connected in the very same way in all particulars, and should be the same size throughout, also having the same fall or pitch as the flow pipe. It is a good plan, and one that looks well, to keep the flow and return pipes on the same pitch; and as the branches from the main lines must cross one or the other of the pipes in a case such as in Fig. 26, it would be better to have the return pipe on the bottom, hanging, if there is room below, on the same hangers directly under the flow pipe; only allowing room enough between them to turn the fittings, or to allow for pipe covering, should it be a place where covering is necessary. And the return pipe, being under the flow pipe, would be in the proper position to connect with the bottom of the boiler without having to cross any other pipe.

To find out the size of main pipe necessary to supply any number of either steam or hot-water radiators, this same principle is the best and surest plan to go by, as you have no figuring to do, and you will be always sure to have the pipes large enough. A riser may have four or five radiators on it, and to find out what size fitting or opening should be left for it on the main, it will only be necessary to consult the list of the size of openings or inlets and outlets of the style or make of radiators you are going to use, taking the largest number of feet allowed for the smallest tappings. No matter how many radiators there may be on the riser, for example, a 1¼-inch pipe will supply 125 feet of radiating surface. Now, we may have on one riser ten radiators, which would not amount to 125 feet, and yet each radiator will be tapped for one-inch pipe. So that it will be seen that it is not necessary to leave out a connection to supply 10 one-inch pipes; that would be entirely too large.

HIGH OR LOW PRESSURE HOT-WATER HEATING WITH THE SAME PLANT.

In Fig. 27 is shown an arrangement of a hot-water heating plant, for office buildings or domestic purposes, which in some respects is different to the plan carried out in Fig. 10. This arrangement gives ample room for the expansion of the different lines of pipe. And where the lateral branches taken off the risers are long, they should be given as much pitch or fall as the room or space between the floor and ceiling will permit.

Where the upper end of risers are to branch off on both sides on the same level, we should never use the regular tee, as it would not only add very much friction to the flow of the water, and in a great measure retard its motion on account of its being a right angle, but the currents of water would collide with themselves, and in that way would also have a tendency of stopping its motion.

In such cases we should either use the special hot-water double-ell fitting, *A*, as shown in Fig. 27, or the tee and elbow, marked *B*; and for lateral branches, either on the flow or return risers below the top connection, the best fitting to use is what is called the T Y.

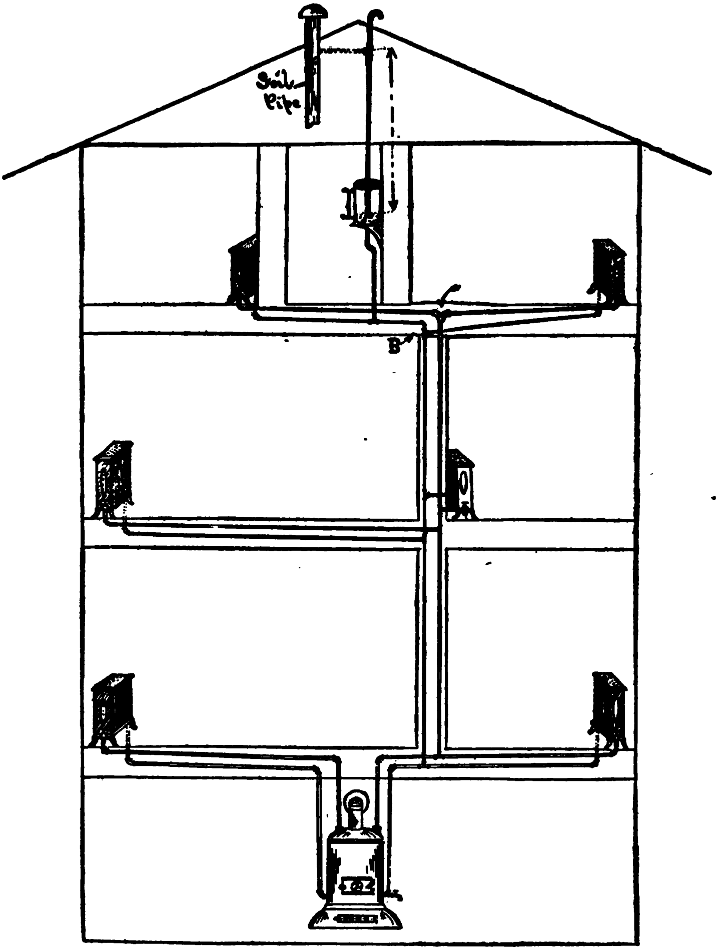

Fig. 27.

It is also a special hot-water fitting, and is the right thing to use on all first-class hot-water work.

THE EXPANSION TANK.

By the arrangement of the expansion tank, as shown in Fig. 27, we can have either high or low pressure, according to the height of the overflow or outlet from the tank; and at the same time having no safety valve or other closed arrangement, but simply a column of water open to the atmosphere. As will be noticed in this plate, Fig. 27, the expansion tank is located on the same floor with the highest radiators, and only a little above them. The tank is perfectly closed at the top, with the overflow pipe extending down on the inside to a few inches from the bottom, and carried up as high as possible for the purpose of getting pressure. It may pass out through the roof, as shown, or may be carried over and connected to the soil pipe, as shown by the dotted lines. I prefer to connect this overflow pipe with some house waste pipe on the inside, as it has some chances of freezing in winter when it passes out through the roof.

In such an arrangement we can carry any low temperature we may desire; that is, the ordinary low-pressure system, from any degree up to 212 degrees, which is the boiling-point.

And should we desire to carry a higher temperature, we can have it by simply allowing the pressure to rise from the heat. The pressure would then rise as much higher in the system as a column of water as high as the overflow pipe from its mouth in the tank to its outlet would give, and therefore increase its temperature due to its increased pressure.

The upper part of the tank acts as an air-chamber, and all the air that escapes from the boiler and through the pipes finds its way to the expansion tank, and escapes to the atmosphere, just the same as in the most simple or entirely open tank. This appears to me to be a safe and economical way of increasing the temperature of the water in the apparatus in extremely cold weather, when it may be desirable to do so.

HIGH-PRESSURE HOT-WATER HEATER.

What is meant by high-pressure hot-water heating is simply the regular piping, such as has been described, or, in other words, any system of piping that will work on the low-pressure system. The special difference between the two systems is, that the outlet or overflow pipe from the expansion tank is fitted with a safety valve, which may be set to blow off or open at any desired pressure. Where high pressure is to be carried or used, there are other things to be considered, a few of which I will mention. As one of the general rules in most things, when we appear to gain some advantage, there seems to appear at the same time some new or unforeseen disadvantage, which about offsets the point gained. And that is the way I might compare a high-pressure system for domestic heating to that of the ordinary low pressure, which is never above the boiling-point.

SOME OF THE DISADVANTAGES WITH THE HIGH-PRESSURE HOT-WATER SYSTEM.

In the first place, all the piping and fittings would have to be of special weight, of a much stronger quality, otherwise there would be great trouble to prevent it from leaking. The ordinary cast-iron radiator would not stand the pressure, as it is now as thin as the best art of casting can make it, in order to compete with the others in prices, and should a radiator burst under a high pressure of hot water (that is, any pressure above the boiling point), it would be many times more dangerous than to have a steam radiator burst under the same pressure of steam,—as will be seen when we consider that one drop of water will increase in size 1,700 times when formed into steam. So that on account of the compactness or density of water lies the danger when heated to a high temperature.

THE EXPLOSION OF STEAM BOILERS.

As a rule, when we hear of a great boiler explosion, or some place blown up by the bursting of some steam boiler, there is great stress laid on the tremendous pressure of the steam, which blew everything to pieces, while some persons were scalded by the escaping hot water, or, in other words, the most blame is laid to the steam. While in all such cases of explosions there is more damage done where the most water happens to be in the boiler at the time of the explosion, there is never much damage done by boiler explosions where there is little or no water in the boiler. And the reason for this is, that water being 1,700 times more compact or dense than steam, will, when let free or allowed to escape to the atmosphere, increase in size in that proportion. This is the reason why, when we draw hot water from a pipe above the boiling-point, it turns into steam at once, and in order to get hot water from such a high head of pressure, we must draw it very slowly.

Going back to our subject on hot-water heating, we will now consider the boiler. The average hot-water heater or boiler on the market would not be safe to use for high-pressure hot-water heating, and therefore this would be another great objection. It, like the average radiator, is made as light and cheap as possible, but is not always sold cheap. Consequently it will be easy to see that to have a proper safe and durable high-pressure hot-water plant for ordinary heating, its cost would be a great detriment to its introduction, and for the heating of dwellings, taking all things into consideration, we have nothing better than the low-pressure system of hot water.

GREENHOUSE OR CONSERVATORY HEATING BY HOT-WATER CIRCULATION.

To give some idea as to the general principle of heating greenhouses, conservatories, or any similar place, we will consider the plant as shown in Fig. 28.

This is one of the most simple arrangements of a hot-water heating plant, and one that has been used more generally and for a longer time than perhaps any other construction. And although it is simple, with little complications to it, yet the general principles of the circulation must be understood in order to produce the best and most satisfactory results. This little plant simply shows the boiler, the expansion tank, and one coil of pipe, but will answer to illustrate its principles better than a more complicated arrangement.

We will presume that we have a cellar under this building to be heated. This is where we place the boiler, as shown in Fig. 28, when we have the room to do so, for the reason that the lower the boiler is the better will be the circulation through the pipes. And in this case, as shown, we carry the flow pipe from top of the boiler around the room, rising a little all the way from the boiler end to the manifold at the opposite side of the room. We then bring back another pipe having the same fall, and connect it near the bottom of boiler at *B;* thus making a simple circuit. At the extreme or high end of the coil is placed a pipe on the upper end

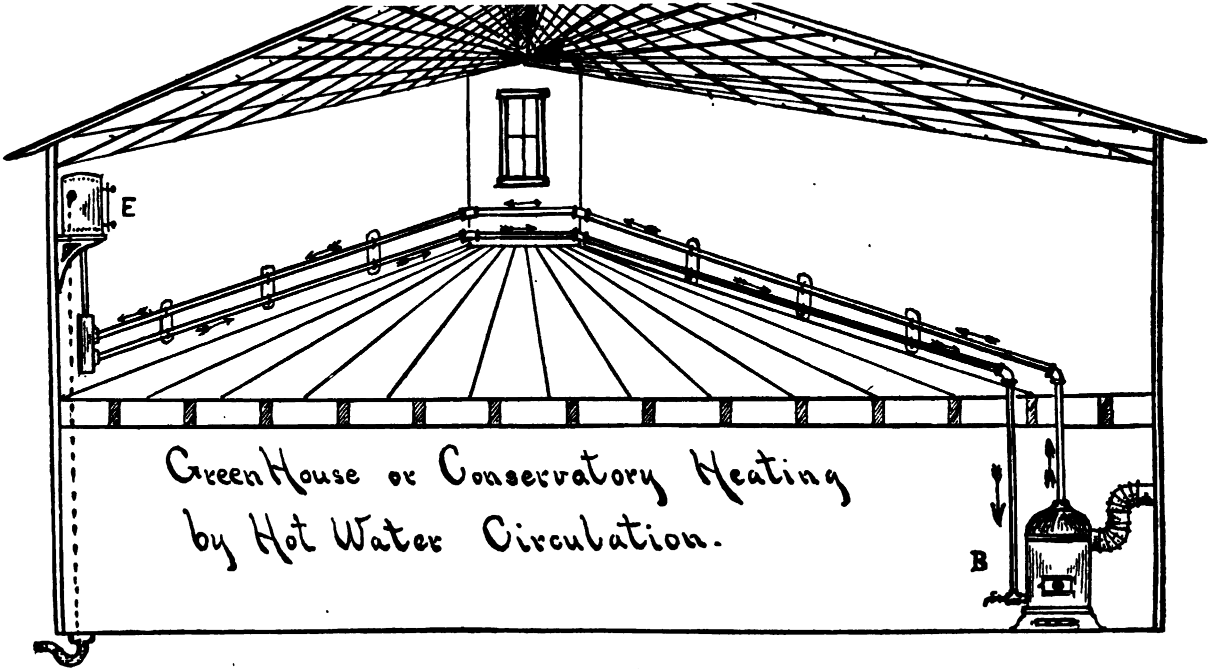
E
Green House or Conservatory Heating
by Hot Water Circulation.
B

Fig. 28.

of the manifold and connected with the expansion tank above it. An overflow pipe connected with the side of the tank, and carried down as shown by dotted lines, makes this job complete. The direction of the arrows shows the direction of the movement of the water in the coil. Both pipes having an elevation from the boiler to the expansion tank, there will be no chance for air to accumulate and remain in the pipes, and therefore we will have a good and easy circulation. This general principle may be carried out for any number of pipes of any size.

TO USE HOT-WATER CIRCULATION FOR HEATING COILS WHERE THEY ARE LOCATED BELOW THE BOTTOM OF THE BOILER.

In Fig. 29 is shown the principle of circulating water through coils where they are located in a pit or below the boiler. It frequently happens that the fitter is called upon to heat places lower than the boiler, or where for some reason or another the boiler is not wanted, or cannot be placed as low down as the coils; and this is a little matter that often puzzles the average fitter. The secret of making a job of this kind work successfully lies principally in, first, carrying the water as high as possible, or as high as the room will permit, and there entering the expansion tank, as shown in Fig. 29; then coming down from the bottom of expansion tank and entering the top or highest point of the coil, as shown.

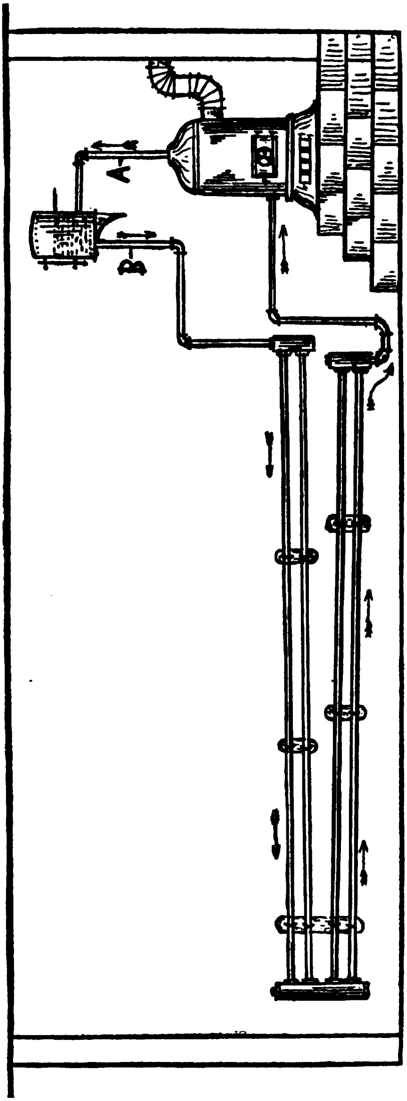

Fig. 29.

It matters not how many coils we place on this circuit; and for illustration we use a four-pipe coil in this case, connecting the upper two pipes to one manifold on the high end, and carried back, where the four pipes all connect to one manifold. The upper two pipes pitch down away from the boiler, and the lower two pipes pitch down toward the boiler, so that both highest and lowest ends of the coil are at the boiler end of the system; connecting the return pipe from bottom of boiler to the bottom of the lowest manifold, or the lowest point in the coil, thus completing the circuit. It will also be noticed in this arrangement that there is no place for air to accumulate or remain in any part of the pipes, which is an important matter that should never be lost sight of.

This being the way such a plant must be constructed in order to work successfully is one matter for the fitter to know, but it is not enough; he should also know why this is the case, and when he thoroughly understands that point he will scarcely ever make a mistake on such work. The circulation of hot water through pipes in a hot-water heating apparatus in the very best and most favorable situations works on a most delicate principle, and where we have such a case as shown in Fig. 29, it is still more so; therefore it does not take much to stop such a circulation, and the greatest care must be taken with it. At this time a little more explanation of its general principles may not be amiss.

In Fig. 30 is shown a balanced lever, or weighing

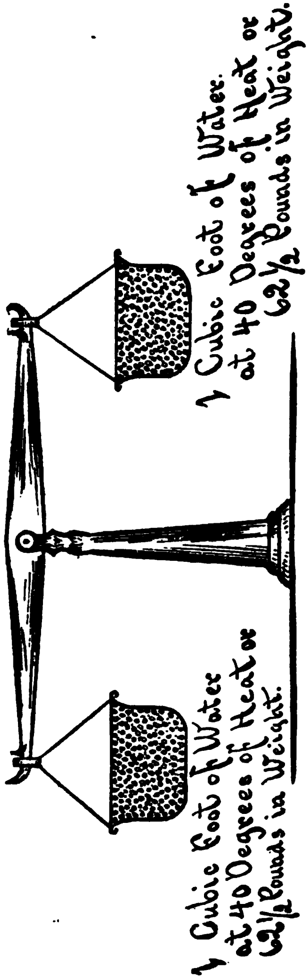

Fig. 30.

scale, and suspended from each end are cylinders or vessels, each holding a cubic foot of water. The water in each of these vessels has a temperature of about 40 degrees Fahrenheit, and the beam stands at a balance, as the weight is the same on each end.

A cubic foot of water at 40 degrees will weigh about 62½ pounds. The small balls in each vessel represent the particles of water, and in these two vessels the size of the particles are shown to be about the same. We will now apply heat to vessel *A* until the temperature of the water in it rises to 212 degrees. The water in this vessel will expand, so that about 2½ pounds of it will overflow the vessel. And now the beam will no longer be at a level, or balance, but rise on the end at *A*, being 2½ pounds lighter, or fall on account of having 2½ pounds more weight on end *B* As will be noticed, the particles will have also changed in size. The particles of water have not changed in their actual weight; they have only become less in number on the light end of the scale, some having overflowed, while all have remained in vessel *B*.

SPECIFIC GRAVITY.

Specific gravity is a term used to show the difference of compactness or density of one substance compared with another; or to show how much more space one takes up than another. I am of the opinion that all matter has the same original weight; that is, if it were possible to weigh one single particle of each kind of matter, they would weigh exactly the same. But when we take their bulk or the space each one occupies, that is another thing. And where one kind of matter or substance takes up or occupies more space than another, it is simply because there is a less number of what I call original particles in it. The following table will show the comparative weights of some different substances compared bulk for bulk:

SOLIDS AND LIQUIDS.

Distilled water	1.000
Platinum	21.500
Gold	19.360
Mercury	13.600
Lead	11.450
Silver	10.500
Copper	8.870
Iron	7.800
Flint glass	3.320
Marble	2.830
Anthracite coal	1.800
Box-wood	1.320
Sea-water	1.020
Whale oil	0.920
Pitch-pine wood	0.660
White pine	0.420
Alcohol	0.800
Ether	0.720
Cork	0.240

GASES.

Pure, dry atmospheric air	1.000
Carbonic acid gas	1.520
Oxygen	1.100
Nitrogen	0.970
Ammoniacal gas	0.580
Hydrogen	0.070

In Fig. 31 *A*, on the end of the beam might be considered the flow pipe in a hot-water heating apparatus, and *B* the return. The cause of the water's motion is

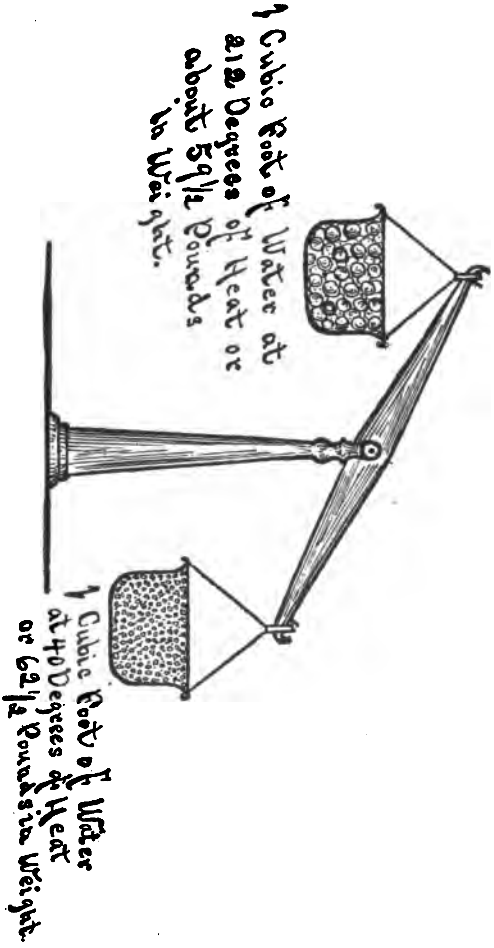

Fig. 31.

due to the difference in weight between the water contained in flow pipe *A* and return pipe *B*. If we could always get a difference between the two lines of 2½ pounds, we would have very little trouble in getting the water to circulate through most any arrangement of pipes. But the very small difference which we do get in the ordinary constructed heating apparatus is so very little, that when we understand it, we will see how necessary it is to use the greatest care in getting the proper elevations to our pipes, and avoid air pockets or anything that would have the least tendency to the stoppage of the flow of the water.

I do not consider that this motion in hot-water pipes is due to the difference in head, or can it be considered in that light. Referring back to Fig. 29, we will notice that, as far as the pressure of water from its head is concerned, there would be as much in flow pipe *A* from the boiler to the expansion tank as there would be in supply *B* from the expansion tank to the coil. Therefore it will be seen that the only motive power we have to cause the circulation in this case is the difference in weight between the water in pipe *A* and pipe *B*. And in such a plant as shown in Fig. 29, there would not be more than about 10 degrees, and often less, between the water in *A* and that which is in *B*. Presuming the water in flow pipe *A* to be 10 degrees hotter than the water contained in pipe *B*, and considering that a cubic foot of water, with a rise in temperature of 172 degrees, or from 40 to 212 degrees, the boiling-point, loses in weight 2½ pounds—so that should we have a change of only 10 degrees in temperature in vessel *A*, Fig. 31, we should only have a difference in weight of about 2 ounces in place of 2½ pounds—and when we consider how much less than a cubic foot of water we have in one of these pipes, we may form some idea as to what amount is left for motive power to cause the circulation in such a plant. One of the best things to do to improve the circulation in such a case as Fig. 29 is to cover flow pipe *A* with some non-conducting material, keep it as warm as possible, and expose pipe *B* to the action of air as much as possible, in order to secure the best results.

HOW TO UTILIZE THE HOT WATER IN THE ORDINARY KITCHEN RANGE BOILER FOR HEATING PURPOSES.

There is a large amount of heat wasted through the kitchen range boiler that might just as well be utilized for heating some part of the house, and at little expense. The writer has taken advantage of this in a large number of cases during the last twenty years, and every job has proved to be most satisfactory.

In Fig. 32 is shown the general principle of how this hot water is caused to circulate through radiators or coils. *A* in this figure represents the water-heater in the range, sometimes called the water-front, and sometimes the water-back; *B* represents the range boiler. The heater and boiler in this case are a hot-water plant in themselves, and work exactly the same as the hot-water heater described, with the boiler in this case taking the place of a radiator. The water circulates from the boiler down through the bottom and along the lower pipe to the lower connection of the heater; then as the water receives the heat it rises and ascends out through the upper connection, and enters the side of the boiler, there rising to the highest point in the boil-

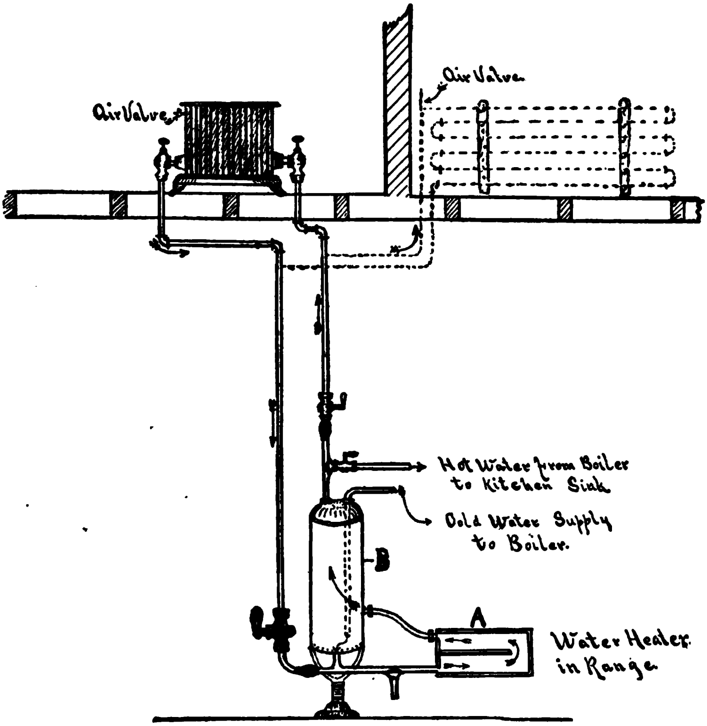
Air Valve
Air Valve
Hot Water from Boiler to Kitchen Sink
Cold Water Supply to Boiler.
B
A
Water Heater in Range.

Fig. 32.

er, thus keeping up the circulation as long as there is any difference in temperature between the water in the boiler and the air surrounding the boiler. To heat a radiator or coil from this hot water, we connect to the hot-water pipe above the boiler, and carry it direct, and with as much elevation as we can get, to the radiator, as shown, and connecting with the opposite end the return pipe, which is carried down and connected with the bottom connection of the boiler. As is the case in all hot-water heating, it will be necessary to place an air valve on the radiator for the purpose of allowing any accumulated air to escape. By this sort of connection we produce a circulation in itself, independent to the water-back, and will vary according to the temperature of water in the boiler. The return water from the radiator may pass up into the boiler without going around the water-heater, or it may pass along the bottom pipe directly to the heater, and make the entire circuit as shown by the arrows. There may be any number of radiators, or radiators and coils, in this system as well as any other, according to the amount of hot water or the capacity of the heater. Coils may be used as shown in Fig. 32 by the dotted lines; having a good size air chamber at the top connection, with an air valve, as in cases of this kind, where so much water passes in and out of the boiler for kitchen use, a large amount of air comes with the cold water and finds its way to the highest parts of the system.

Another way of connecting for heating purposes is to carry the hot-water pipe from the heater directly up to the radiator or coil, with a branch taken off at the top of the boiler and connecting therewith. In this case the hottest water would have a tendency of going direct to the radiator as it comes from the heater, without mingling with the water in the boiler. Stop-cocks are placed on the flow and return pipes near the boiler, so that the water may be turned off from the heating plant in summer.

EXPANSION TANKS.

There are a large number of different kinds of expansion tanks; and until within the last few years every hot-water fitter made his own tank, using light galvanized sheet-iron, in some cases entirely open, so that the hot water in it will have all the chance in the world to evaporate, at times filling the house with steam, and in other cases a loose cover was used. Some use square cast-iron tanks made for the purpose, and in many cases I have noticed a regular water-closet tank used for an expansion tank.

In late years there have been great improvements made in every detail of the hot-water heating apparatus, so much so that there are to-day manufacturers who make a business of manufacturing special fittings and appliances for the hot-water trade, and among them we have manufacturers of special expansion tanks; and, as a rule, there is nothing as good as the article that is made specially for the use to which it may be put. If a thing is worth doing at all, it is worth doing well, and this rule applies quite forcibly to the heating of a house; it is the little appliances that make any piece or system of work the most satisfactory, particularly when the special article costs no more, or only a trifle more.

The best tank to use, according to my idea, is a good, well riveted, galvanized sheet-iron tank, having the head riveted on as well as the bottom, and tested to stand from 100 to 200 pounds pressure per square inch, having gauge glass and cocks, so as to show the height of the water, and properly tapped out with the screw threads to receive the expansion pipe, the water-supply pipe, and the overflow. Soldered joint connections should not be used on such work; it is also very poor judgment to use a tank having a loose cover, as there might be great damage caused from water overflowing such an arrangement.

AUTOMATIC FEED EXPANSION TANKS.

It is also a very safe and good plan to use an automatic water feeder on all expansion tanks, as it prevents the water from ever becoming too low in the system, as well as saving a large amount of labor and annoyance.

In Fig. 33 is shown a most complete arrangement of an expansion tank manufactured by your humble servant at 187–189 Mercer Street, New York City. The tank is arranged with a long glass gauge and gauge cocks, also an automatic water feeder, which is applied to its side; the feeder, being quite small, takes up no special room other than the space occupied by the tank, and also makes a very neat appearance. The advantage of such an arrangement is that it enables us to use a tank having solidly riveted heads, and at the same time having it automatically supplied and occupying a small space; also the advantage of having the entire capacity of the tank for the expansion purposes, as the feeder may be placed low enough to stop the line of water at the bottom of the tank.

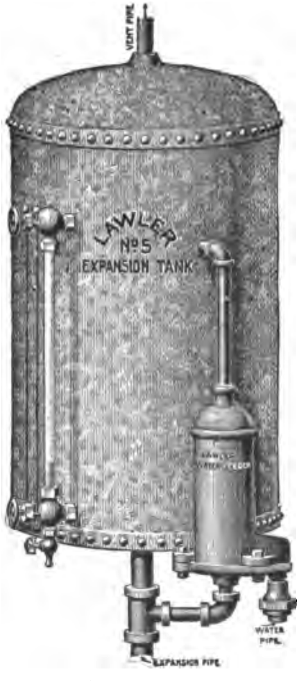

Fig. 33.

The following is a list of Sizes and Capacities of the Lawler Expansion Tank, which makes it very convenient for the fitter to select the size he may want for any capacity.

No.	SIZE.	Capacity in Gallons.	Capacity in Square Feet of Radiating Surface each Tank will Carry.	Price Complete with Feeder and Water Gauge as Shown.	Price of Tank and Water Gauge without Water Feeder.	Price of Tank only.	Price of Water Gauge as Shown.
0	10x20	8 Gallons	160 Sq. Ft.	$18.50	$8.50	$7.00	$1.50
1	12x20	10 "	200 "	19.50	9.50	8.00	1.50
2	12x24	12 "	250 "	20.25	10.25	8.50	1.75
3	12x30	15 "	325 "	20.75	10.75	9.00	1.75
4	12x36	18 "	450 "	21.50	11.50	9.50	2.00
5	14x30	20 "	500 "	24.25	14.25	12.50	1.75
6	14x36	24 "	600 "	25.00	15.00	13.00	2.00
7	16x30	26 "	650 "	26.00	16.00	14.00	2.00
8	16x36	32 "	800 "	27.00	17.00	15.00	2.00
9	16x48	42 "	1050 "	28.50	18.50	16.50	2.00
10	18x60	66 "	1650 "	43.00	33.00	31.00	2.00
11	20x60	82 "	2050 "	49.00	39.00	37.00	2.00
12	22x60	100 "	2500 "	63.00	53.00	51.00	2.00
13	24x60	120 "	3000 "	80.00	70.00	58.00	2.00

SPECIAL HOT-WATER FITTINGS.

The fitter who uses the regular steam fittings for hot-water work makes a great mistake, and in more than one way. If he will give the matter a little thought he will soon see wherein he makes it. In the first place, the special hot-water fittings cost a little more than the regular fittings, and this is the reason why they are not used more generally. There is no fitter who will not agree that the special hot-water fittings are the best for hot-water work, and make a more satisfactory job. Still they take the chances of getting a good enough job with the old fitting; and perhaps because they have to figure closely, and cannot afford to use anything that would add in the least way to the cost, while the old style fitting would answer. I claim that a hot-water plant fitted with the special hot-water fittings will give enough more heat than the plant fitted with steam fittings to more than make up for the extra cost of the special fittings by reducing the amount of the radiating surface. That is, if it takes 500 feet of radiating surface to heat an ordinary dwelling-house by using the cheap, or steam, fittings for hot-water work, 450 feet of radiating surface will heat the same house in a more satisfactory manner when the special hot-water fittings are used. This is a matter that very few fitters ever take into consideration, and when all things are considered, it will be found that the special hot-water fitting job is the cheapest. Fig. 34 shows the style of the special hot-water elbow. It is simply a long, curved elbow, having much more radius than the regular steam fitting. But the difference which it makes to the flow of the water through it is that it reduces the friction of the water to about four times that of the regular fitting. Fig. 35 represents the special hot-water cross and Fig. 36 the double branch ell. These fittings are also made in reduced sizes, so that it is not necessary to use bushings with them. Another great advantage which these special fittings has is, that they reduce the number of fittings on a job, as one of these in many cases will answer where two of the other style fitting must be used. The eccentric fittings are also very good, and can be used in many places to great advantage. The

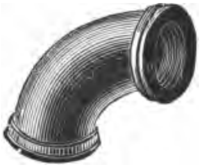

Fig. 34.

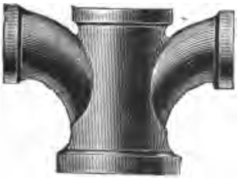

Fig. 35.

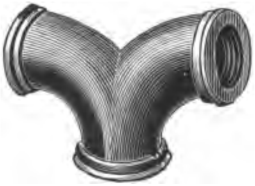

Fig. 36.

following plates, Figs. 37 and 38, will show where the special hot-water fittings can be used to much advantage.

SINGLE-PIPE HOT-WATER WORK.

In plate, Fig. 37, is shown a system of hot-water heating, or what might be called the one-pipe system, and should be interesting to the fitter who wishes or intends to be up to date (as the expression goes) in hot-water heating.

There are many ways in which great improvements can be made in this branch, and they will be made, because the more experience we have, the more ways we discover to simplify the work. In Fig. 37 is shown a hot-water plant, having the boiler located, as shown, in the cellar, with only one flow pipe and two return pipes, one on each side of the boiler. The flow pipe is carried to one side after leaving the first piece of pipe on the boiler. This is for the purpose of expansion. It is then carried up the entire height and connected to the expansion tank. Near the ceiling of the first floor is placed a cross on the flow pipe of the special pattern, and reduced in size on the top for the expansion pipe. From each side of the cross is carried lateral lines of pipes, inclining down from the rising flow pipe, taking in on its way such radiators as may be in that locality of the house, and then following to the cellar, and going back to the bottom of the boiler.

The first fitting on the right side lateral line, marked

No. 1, is a special hot-water T Y, with its outlet looking straight up. Fitting No. 2 is a special eccentric hot-water fitting, so that its outlet points to the side in the direction of the radiator, while Nos. 3 and 4 are the

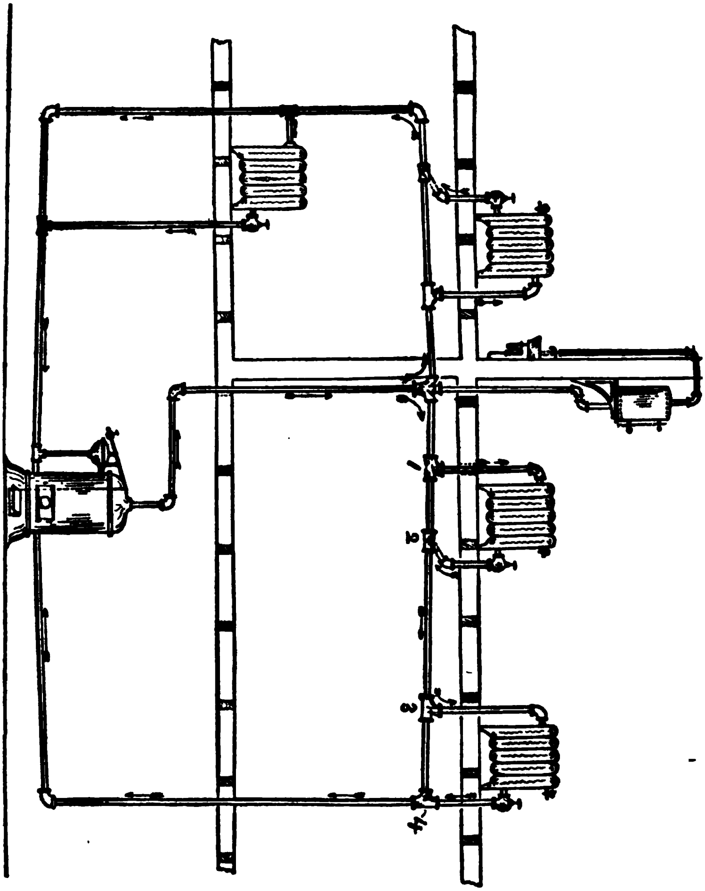

Fig. 37.

same as No. 1 T Ys and placed as shown. The hot water rising in the main flow pipe passes up to the top connection of the radiator through fitting No. 1, and returns to the same pipe after passing through the radiator and through fitting No. 2; thus making a circuit. The coldest water, after coming from the radiator, will remain at the bottom of the main pipe, while the hottest water flows along the upper part of it. The same principle is carried out in connecting the next radiator, all the water from this side of the system finally passing down and back to the boiler; thus making a complete circuit through that side. On the left-hand side, the first radiator from the main upright flow pipe is connected, the same as described on the right-hand side, with the special fittings. The lateral pipe on this side, after supplying the hot water and receiving the return water from the first radiator, descends downward, and takes in on its way another radiator situated on the first floor, branching in on the top connection of this radiator, and then continuing down to the cellar, where it is carried along to the bottom of the boiler; the outlet end of this last radiator is connected with a separate pipe, which is carried straight down and connected to the return near the cellar floor, it being about as near as to return back and connect with the downward vertical line, at the same time being much better for the circulation.

The three upper radiators will require air valves to allow the air to escape from them. But the lower radiator will not require one, as the air that may find its way there will pass out through the inlet or upper connection, and go direct to the expansion tank. This makes a good, practical, as well as cheap hot-water job, and the only thing to be careful about is to have the lateral lines of good size. They should be one size larger from the first eccentric tee, No. 2, to the last T Y, No. 4, on the right-hand side; that is, one size larger than the first two pieces nearest to the cross, and one size larger than the vertical return line—for the reason that we divide the water in the horizontal line, and the size pipe that is large enough to supply the whole number of radiators on one line will do for the first two pieces. Then from fitting No. 2, and including it, we increase the size, and carry this increased size to and including fitting No. 4. And, again, the bottom part of fitting No. 4 may be reduced in size to that of the branch or size taken off the cross or vertical flow pipe. On the left-hand side of Fig. 37, the first four pieces of pipe starting from the cross, down to where it enters the lower radiator, should be one size larger than the next two pieces on the line, and increasing one size larger from where the return of the lower radiator connects to the lower horizontal return pipe. By the use of the special fittings, and the proper size pipes placed as described, there will be no trouble in carrying out this system in the most successful way.

Another application of the one-pipe hot-water system is shown in plate, Fig. 38, which might be considered a little more on the order of the one-pipe steam system. It will be noticed that in all cases we get a separate circulation through each radiator in one way or the other. This is necessary, as it would not do, with the ordinary size radiator connections, to use one opening for both inlet and outlet, as in the case with the one-pipe steam system. This is easy enough with steam, for the reason that there is so much difference between the density of the steam and that of the water; one being very much elastic, and the other being quite solid. But in the case of hot water we get no such difference, as the two currents of water, if we could establish them in opposite directions through the same opening on a radiator, would differ in such a small degree, and that in their temperature only, that it would scarcely be perceptible in such a small pipe, and would not be of any practical good.

Therefore, in all cases we must use two connections to the ordinary radiators for hot-water heating. In Fig. 38 we have what might be called a trunk line of flow pipe; fitting No. 1 being large enough to carry double the capacity of pipe No. 2, or as much as both Nos. 2 and 3. This trunk pipe may then reduce in size after it passes the second cross from the bottom, reducing again after passing this cross, or, in other words, as the radiation is becoming smaller. This plan differs very much from that shown in Fig. 37, as all the water in this case must pass up through one

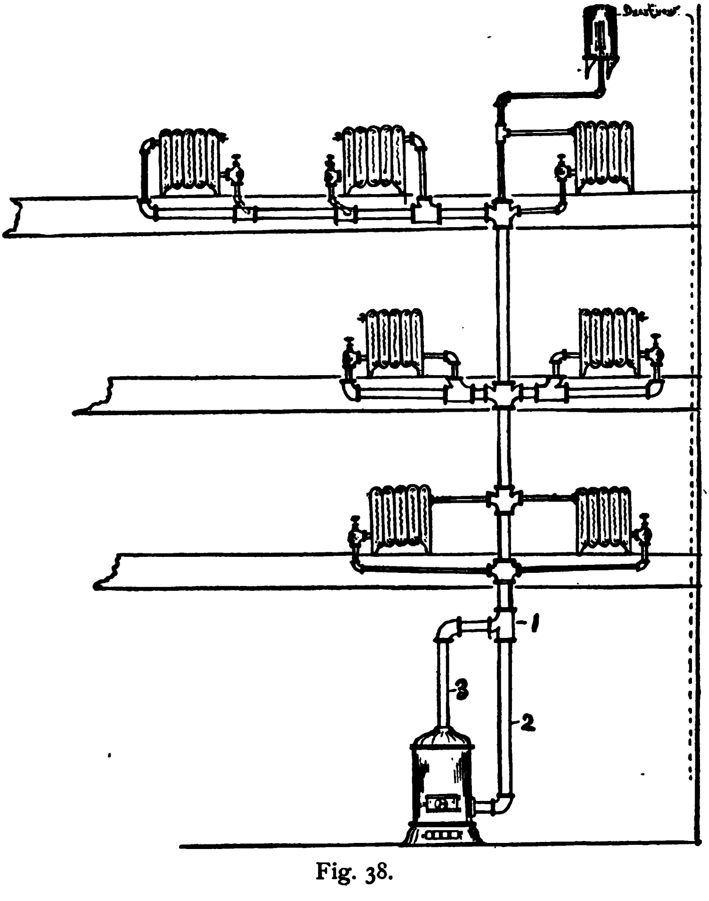

Fig. 38.

connection and down again through the same connection. And for this reason the size is very important in this case. Referring to the two upper radiators on the left-hand side in Fig. 38, it will be noticed that the lateral line from the upper cross has an elevation to the last connection, and on this line is used again the eccentric tees, also the T Y placed in the same position with flow or supply, taken from the top of the pipe and carried to the top connection of the radiators, with the return coming back from the bottom connection of the radiators and connecting to the side or bottom of the lateral line. In this case, in the upper lateral line of pipe we will have two currents of water, and in opposite directions, as well as in the vertical pipe shown in this plate, as stated before. The only thing to be careful about is to get the pipe large enough, with the fittings placed properly, and of special make. In this plan, Fig. 38, the two lower radiators and the radiator on the right-hand side require no air valves, as the air will pass through the supply connections to the trunk and find its way to the expansion tank. The other radiators in this system require air valves, as they are supplied from below the upper connections. In Fig. 38 is shown four different ways of making the connection to the radiators, and are placed here for the purpose of showing different ways of connection, and at the same time get a circulation through the radiator. In this case, of course, there are preferences. The best way of getting a quick and thorough circulation in any case is to connect the flow pipe at the top of the radiator at one end, and the return at the bottom of the opposite end. But it is not always handy to do that, and in many cases it does not look quite so well. Therefore, it is well to know what we can do when we meet these different situations. In plan, as shown in Fig. 38, we will not only have rising and falling currents in the vertical flow line, but we will have side currents passing in and out, consequently having quite a conflicting action on each other. And yet, if properly connected, using the proper and right size pipe and fittings, this is entirely practicable. We have local and conflicting currents in nearly all hot-water pipes, and cannot prevent them; and in such a case as this we only increase that element, but make some provision for it by the use of special fittings and enlarged size of pipes.

STEAM HEATING.

THE PRINCIPLES INVOLVED IN THE APPLICATION OF STEAM TO THE HEATING AND VENTILATION OF VARIOUS KINDS OF BUILDINGS, AS PRACTICED IN THIS COUNTRY.

It is not my intention to give here a history of the discovery of steam, or who first made use of it for the purpose of warming buildings. As this book is not intended for that purpose, but for the purpose of giving, without the waste of time or space, practical instructions, gained from actual experience on the methods of how the various details in this branch of mechanics are carried out, to those who may have a desire for such information, and with a hope that they may gain something thereby. The heating of buildings by steam is carried out by three different principles, or, in other words, the steam used for this purpose is procured from three different sources. The first, or what is called the low-pressure system, is where we have a boiler located in or about the premises to be heated, and which is intended for that purpose alone, and must be large enough to properly heat the building it is intended to heat without having to carry more than about five pounds pressure of steam per square inch; and with this low pressure making it practicable to carry back all its condensed steam to the boiler again after parting with its heat, without the aid of any special mechanical arrangements or power other than its own gravity .And hence this arrangement is called the gravity system. The second principle upon which steam is used for heating purposes is where the steam is taken from some power boiler, or where a boiler may be used to furnish steam for the purpose of running some stationary engine, or for any other purpose where it is necessary to carry a higher pressure of steam than five or ten pounds, say from 30 to 80 pounds pressure, or more. Taking our supply of steam for warming purposes from such a place is called the high-pressure steam system. And in this case it differs somewhat from the first mentioned, not only because the supply of steam is taken from a different source, but because the condensation from the cooling of the steam is not always carried back to the boiler from where the steam was taken; because this boiler having a high pressure, the condensation could not return back by simple gravitation alone. And on this account, in some cases, this condensation is allowed to run off and waste in some drain, while in other cases it is saved and made to return to the boiler by the aid of a pump, or other mechanical arrangements called return steam traps. It is also customary and proper in this high-pressure system to place on the main supply pipe near the boiler what is called a reducing valve, so that we can carry any amount of pressure we may see fit, no matter what the pressure may be on the boiler. And this is quite desirable, because there will be less strain to the heating apparatus, and also less danger from spontaneous combustion taking place by some woodwork being too close to the heated pipes. The third system or principle of heating by steam is called the exhaust system, and that is where we use the waste steam from the exhaust pipe of some stationary engine. This is a principle that is used more generally in factories and buildings where there is much steam used for power purposes, and it is coming into extensive use. There are very few factories at the present time using live steam for heating purposes, as it is equal to receiving the heat free of charge. This principle also works very satisfactorily when constructed by men of experience in this branch. In the low-pressure steam system every kind of radiating surface is used, the ordinary pipe coils, direct radiators, direct indirect radiators, and indirect radiators, and it is used more especially for churches and private homes. In constructing a heating plant on the low-pressure plan, there are a few general principles to understand, and which must always be considered, in order to produce the best results. Having a thorough understanding of these things, the fitter will be enabled to carry out his work in a most successful manner. And without a proper understanding of the principles of steam circulation, no matter how much of a mechanic he may be, there will be nothing certain in regard to how the apparatus will work when completed by such a person. It is also a dangerous thing in many ways for a person to undertake a piece of important work which he does not thoroughly understand, or without having some one who does understand it see that it is carried out correctly.

In the first place it will be necessary to have a boiler to generate the steam, and as the condensed steam is to return again to the boiler from whence it came, and simply by its own weight, it will be necessary to locate the boiler at a lower point than any radiator to be heated by the steam, therefore it is placed in the cellar of the house, or some place made for it at a low elevation; and as steam is 1,700 times lighter than water, it would naturally find its way to the highest point of a pipe or vessel containing it, while water in the same vessel would remain at the lowest possible point. Steam, being so light, condenses quite rapidly in a heating apparatus, and as it must travel so fast to make up for the condensation, there should be the least possible resistance to its flow from the boiler to the radiators. All sharp curves should be avoided as much as possible. The pipes should be large in size, and also pitched in such a way that the steam that may condense on its way to the radiators can be carried off through branches in the bottom of the main steam pipes, in order that such water from condensation will get out of the way and not block up the space or room in the pipes that is intended to convey the steam to where it may be wanted.

If we consider that the movement of the steam through the steam-supply pipe is nearly 1,700 times faster than the movement of the water as it passes into the boiler through the return pipe, it will be more easy to understand why there should be the least obstruction to the flow of the steam, and also the reason why the flow pipe should be at least one size larger than the return pipe for such work. And for two special reasons we should avoid as much as possible the condensation of steam in any supply pipe: first, for the purpose of delivering to the radiators dry steam, that it may do more effective work; and second, that there may be the least condensation in the steam-supply pipes to stop the flow of the steam. There are many other good reasons why the supply pipes in a steam plant should be covered with some good non-conducting covering; as a rule no person wants their cellar heated up, and any heat given off from pipes where it is not wanted is simply a loss of that much heat. And if persons who have steam plants in their houses saw the amount of coal being wasted or thrown out with the ashes that is required to produce the amount of heat going to waste where pipes are not properly covered, they would soon look into the matter and have it stopped, and attend to the covering of their pipes.

TABLE OF CAPACITIES OF SUPPLY AND RETURN PIPES FOR LOW-PRESSURE STEAM HEATING.

Size of Flow Pipe.	*Will Supply Sq. Ft. of Radiating Surface.*	*Size of Return Pipe.*
1 inch	100 to 140	¾-inch.
1 "	125 to 170	1 "
1½ "	175 to 250	1¼ "
2 "	300 to 500	1½ "
2½ "	600 to 800	2 "
3 "	1000 to 1300	2½ "
3½ "	1500 to 2000	3 "
4 "	2500 to 3000	3 "

The above table is intended for ordinary house heating, and not for longer lengths than are generally used on such work. Where there happens to be a large horizontal line, both supply and return pipes should be larger in proportion to the extra distance from the boiler.

SIZE OF TAPPINGS OF STEAM RADIATORS FOR PIPE CONNECTIONS.

The outlets for pipe connections on the average standard make of direct radiators are, for the two-pipe system, as follows: All radiators of 50 square feet, or smaller, 1-inch by ¾-inch, and are right-hand threads; all radiators larger than 50 square feet, 1¼-inch by 1-inch, right-hand thread. These radiators are all tapped for ⅛-inch air valve, right-hand thread.

TAPPING FOR ONE-PIPE WORK.

All radiators of 30 feet and smaller, 1-inch, right-hand thread; all radiators larger than 30 and smaller than 60 feet, 1½-inch, right-hand thread; all radiators larger than 60 feet, 1½-inch, right-hand thread. For the two-pipe steam work radiators are tapped out when ordered for both connections at the same end, but not unless ordered that way.

TWO-PIPE STEAM JOB.

In Fig. 39 is shown a simple two-pipe steam job which will answer to illustrate the general principles upon which all low-pressure steam-heating plants must be carried out in order to work successfully: first rising from the top of the boiler with the main steam pipe to a high point near the ceiling, then gradually inclining down from that point until it passes the last radiator connection, where it then drops down and is connected to the return pipe below the water line in the boiler. The dotted line shows the height of the water in the boiler, and also where the level of the water should be in all the return pipes. On a two-pipe job it is always the best plan, if possible, to carry the return pipe from each radiator to a point below the water level before connecting with any other pipe; in this way there will be no interference of the circulation of one with another. This is the reason why the last return pipe on the return from the farthest radiator in Fig. 39 extends down to

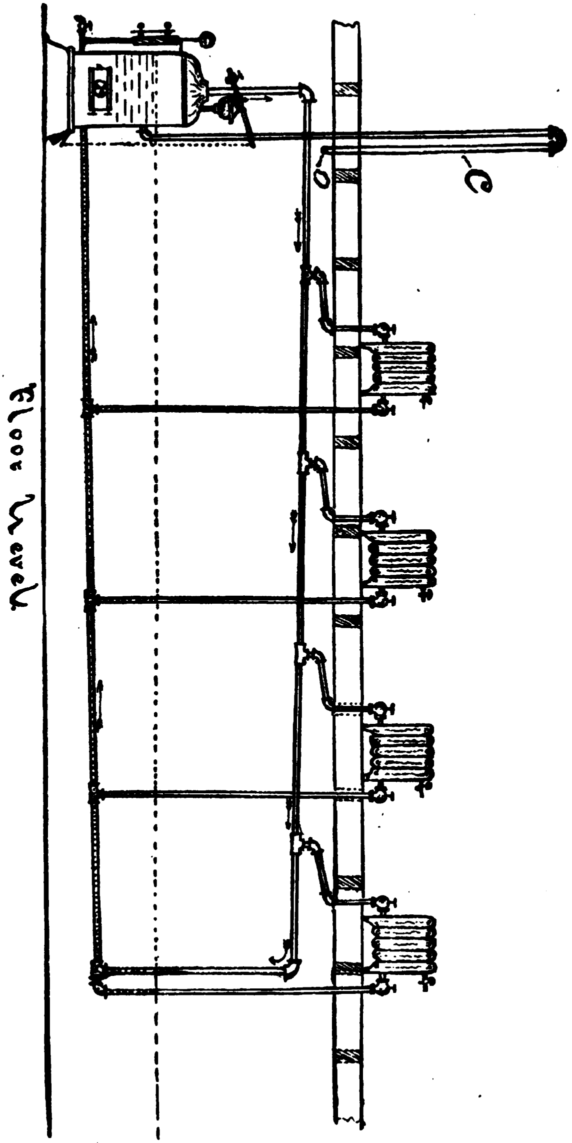

Fig. 39.

the bottom main return pipe before it connects therewith. Of course in this case, and in all cases of steam work, it will be necessary to have air valves on the radiators, no matter what make the radiator may be, whether direct or indirect; and as a rule there will be considerable trouble with any system of steam heating unless each radiator has a good automatic air valve. The reason of this is that in a steam plant for low-pressure heating, or such as is used for domestic heating, the very uneven flow of the steam from the boiler allows air to accumulate in the radiators, so often that if there was no person present each time to allow the air to escape, the radiators would remain cold most of the time where the regular non-automatic valves are used, and hence an uneven temperature of heat throughout the house is the result. It is not an easy matter to get a good automatic air valve, but they can be had by paying a proper price for them. There are several makes of automatic air valves on the market intended for the purpose, but the great object appears to be to see who can make a thing the cheapest, and yet pass it off for an automatic air valve. If you are in the steam heating business to stay, it will pay you to use the best kind of automatic air valve, even if you have to pay much more for it; because the successful operation of a steam plant depends a great deal more on the little air valves than most persons think. I have often seen first-class steam jobs spoiled by simply trying to save two or three dollars in using some cheap or non-automatic air valve on the radiators.

This same principle holds good in regard to the automatic regulation of the steam boiler; and the steam boiler without the best automatic regulating fixture is both dangerous and extravagant. For a steam plant to come anywhere near keeping up a continuous supply of heat, it will have to be equipped with automatic regulating fixtures, otherwise it would require a great amount of attention by some of the occupants of the house; and, therefore, the boiler should be made as near automatic as possible; using an automatic damper regulator, and also an automatic water feeder. The damper regulator would take care of the drafts as the pressure of steam would rise and lower, and the automatic water feeder would not only make the boiler more *safe* by keeping enough water at all times in it, but would supply the boiler, *gradually* letting in perhaps not more than a tablespoonful at a time; and in this way would not have much effect in changing the temperature of the water or steam in the boiler. The steam boiler should also have a good water column with glass gauge and try-cocks, so that it would be easy to see the height of the water in the boiler. The water column should be connected to the boiler direct, on the top end above the water line, and on the bottom end to the boiler considerably below the water line. It is also necessary to have on a steam boiler a reliable steam gauge, in order to tell the pressure of steam; and this gauge should be connected as direct as possible to the steam chamber of the boiler in order that nothing but the pressure of steam may affect it. Sometimes where steam gauges are connected to return pipes as well as to the boilers, they may be affected by the height of a column of water in the return pipe without having any steam pressure, and therefore it would be better to connect the steam gauge direct to the steam chamber of the boiler only. This gauge should be be taken off occasionally and tested, and also see that its connection to the boiler is not filled up. Another thing perhaps more necessary on the steam heating boiler than any of the fixtures mentioned is a safety escapement, or safety valve.

And as the low-pressure steam system is intended to give the required amount of heat without carrying more than 5 pounds pressure per square inch, it will be an easy matter to construct an open column, as shown in Fig. 39, marked *O C*. This is simply a pipe 1 inch or more in diameter connected to the boiler a few inches below the water level, and carried up about 12 feet high, as direct as possible, using a return bend at the top, and carried down again below the cellar ceiling, and there left open at the end. Should more pressure rise in the boiler than the amount it is intended to carry, it will force out the water until the water in the boiler falls below the point where the pipe column is connected, then the steam will find its way out and be relieved of the extra pressure. This is a more safe way than to use a safety valve, as the valve may become corroded solid and might fail to work at the proper time.

LOCATION OF THE STEAM BOILER.

In regard to the location of the steam boiler. As well as being placed low down, or below the radiators which it must heat, the boiler should be placed as near as possible in a central position, in order to make the runs as short as possible. Although steam has the advantage over hot air furnaces of doing its work from a greater distance, yet its best place is as near as possible to the radiators that are to be heated.

In Fig. 40 is shown another plan of the two-pipe steam system, having a few little points which do not show in Fig. 39. On the left-hand side of the boiler, Fig. 40, is a branch taken from the main steam pipe and carried over some distance, having also a fall from the boiler. This piece of supply pipe has a tee on its end looking up, and also looking down. The tee, of course, looks up to connect with the riser which supplies two radiators above with steam, and the bottom end of the tee looks down for the purpose of connecting to the return pipe below the water line in the boiler, and thus carrying away any water that may come from condensation in the riser, and also the lateral supply pipe; this keeps the steam as dry as possible to enter the radiators. On

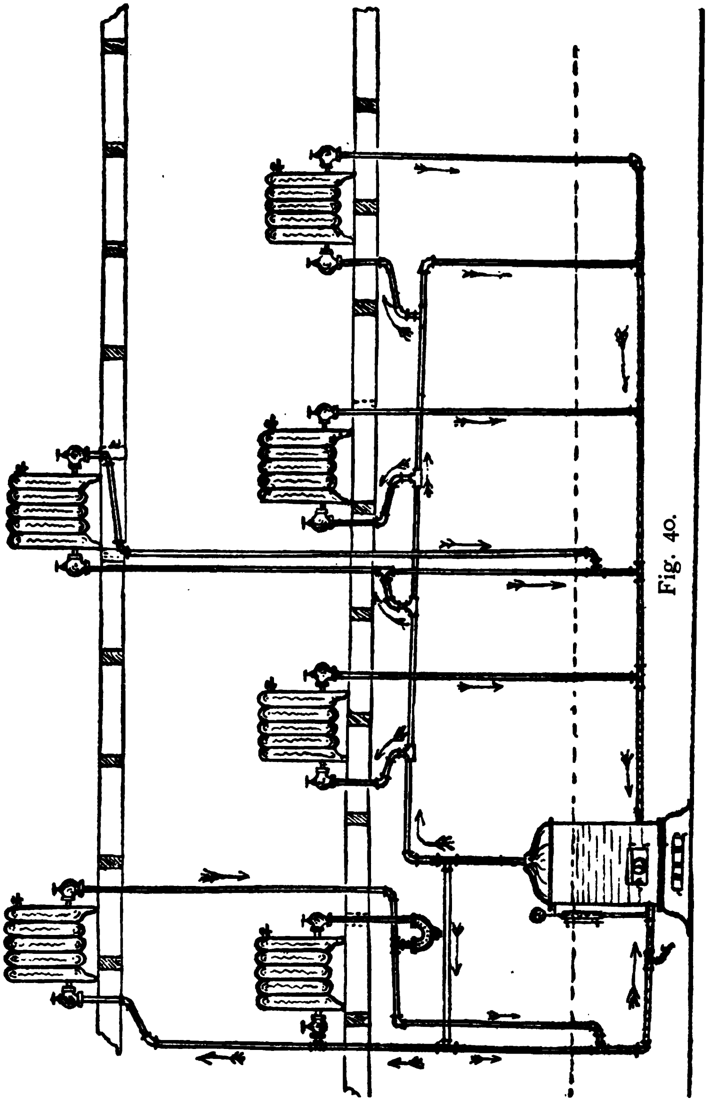

Fig. 40.

this line we connect to the radiator on the first floor, and also to the radiator on the second floor. Now we carry back our return pipe from the upper radiator and connect it below the water line, as shown in Fig. 40. But the return from the radiator on the first floor is not carried down and connected with the main return pipe below the water line in the boiler. And to save a number of feet of pipe, as the distance may be considerable, we only carry this return a little below the horizontal part of the return from the upper radiator, placing thereon a return bend as shown, bringing it up and connecting to the side of the upper radiator's return. This makes a water line for itself, as the water will stand in the return bend as high as its connection with the other return pipe. Should we connect the return from the lower radiator direct to the return from the upper radiator without the water-trap, there would be some trouble with the circulation of the upper radiator, as it would be possible at times to have a complete circulation of steam through the lower radiator before it had gone half way through the upper radiator; there would then be live steam pressing against both the inlet and outlet ends of the upper radiator, which would make its complete circulation slow.

The false water line or pocket, as shown by the return bend, should always be provided with a plug at the bottom, so that the water could be drained off when necessary. It is always better to have a separate and complete circuit, as stated before, for each radiator; but this is impossible in many cases, and besides it costs more. With the two-pipe system of steam heating it is necessary to use two valves for the control of the heat, and on this account there is often more trouble than with the one-pipe system. Many persons in turning off the heat from the radiators close the supply valve only, and forget to close the return valve at the same time, and the result is that the pressure of steam in the apparatus forces up water from the return pipe and partly fills the radiator, which makes considerable trouble and noise when the steam is turned on again.

It is also a very important thing to use the best kind of valve on steam radiators; and the common ground metal seat valve should not be used for this purpose, as there is soon trouble to perfectly close such a valve. On low-pressure steam work the radiator valves should be fully turned on or entirely closed, and this cannot be done unless the valves will close perfectly. Therefore, the best valves to use on radiators are the gate valves, or a good soft seat valve. In the ordinary house-heating work it is scarcely ever necessary to use valves on the main steam or return pipes; and where they are necessary, or specified to be used, if possible use the gate or straightway valve. Globe valves are very bad on such work, as they add much friction to the flow of both steam and water; and should globe valves be used, the fitter must be careful when placing them on hori zontal lines to have the top or stem of valve sideways on the pipe, and in no case with the stem standing up on the top or standing down on the bottom side of the pipes. I have found a large number of steam jobs made very unsatisfactory by globe valves having been placed improperly on some of the pipes. The globe valve, not having a straight passageway through it, forms a trap when placed upright on a horizontal pipe, and therefore should be avoided as much as possible.

A COMBINATION STEAM JOB.

The popular meaning of combination steam heating is where a hot-air furnace has combined with it a small steam boiler intended to heat one or two radiators with steam, situated at some remote part of the house, where it would not be practicable to carry hot air from the same furnace. But this combination steam heating, as shown in Fig. 41, is a different thing. In Fig. 41 is shown a simple arrangement of pipes that may be carried out to some extent and advantage in any low-pressure steam plant. This is called combination, because in the same plant and from the same boiler we use the two-pipe system, the one-pipe system, and also heat a room on the level with the boiler by hot-water circulation. In fitting the hot-water coil, as shown in Fig. 41, on the lower floor, we connect to the side of the boiler two or three inches below the water level, and carry the flow pipe to the coil on an incline down from the boiler, so that the connection at the boiler will be the highest point in the entire circuit, continuing through the coil—or a radiator may be used—connecting the return with the coil to the regular steam return should it be in that locality, and making the circuit back to the boiler, having valves on the inlet and outlet to the coil to control the heat. It would work better to carry a separate pipe back from the coil to the boiler, as indicated by the lower dotted lines. It makes no special difference whether we heat part of the house by the water from the steam boiler, or the entire house by only the steam from the boiler, so far as economy in fuel is concerned, because the amount of heat taken from the water in the boiler by the water coil to warm some portion of the house would be equal to the same amount in the shape of steam that would have to be furnished from the boiler to warm the same space. Therefore, the advantage of this water coil would only be in the convenience of being able to get some heat at a low point where it would not be practicable to heat by steam.

THE TWO-PIPE SYSTEM ON THIS SAME PLANT (Fig. 41).

Carrying up our main steam pipe to a high point in the cellar from top of the boiler, as we did before in Fig. 39, in order to get a good fall down away from the boiler and to the extreme end of the line, our first tee on this main supply is connected to the first riser, which supplies a radiator on three floors; then a line of return pipe is carried down from the upper radiator, which takes in on its way down the return water from the

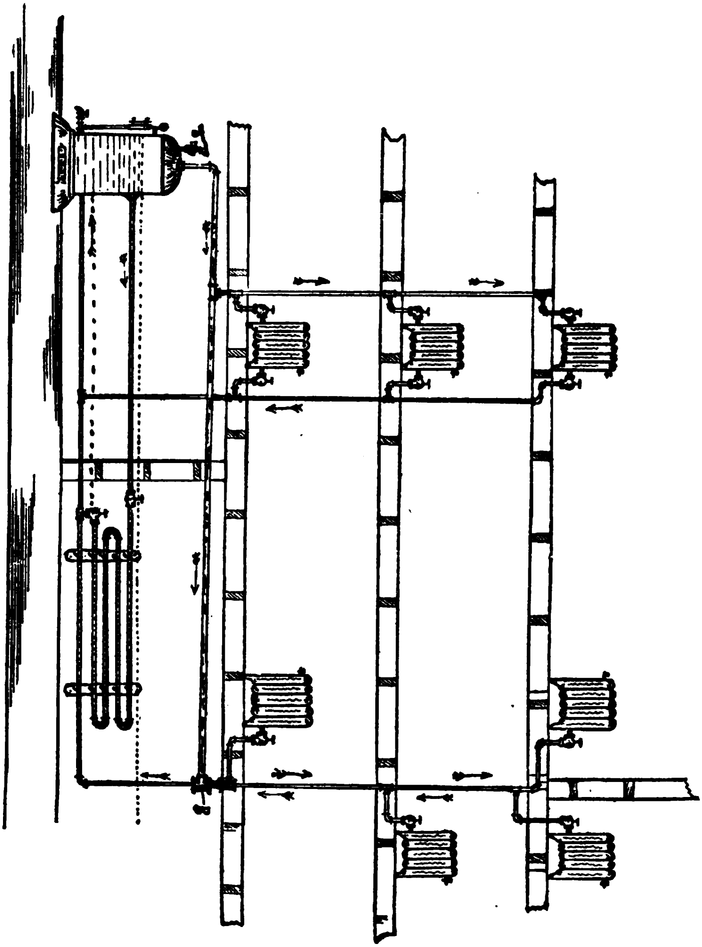

Fig. 41.

other two radiators, and finally ends in the main return in the cellar.

This is what might be called the regular two-pipe system, and the steam or supply pipe may enter the same end with the return pipe side by side without changing the principle of the risers. This is also only a matter of convenience to suit the situation of the radiator, as it might not be possible to always get at both ends of the radiator to operate a valve.

THE ONE-PIPE SYSTEM (Fig. 41).

We will now consider the one-pipe system in this plant. On the extreme end of the main steam pipe from the boiler we place a tee looking up and down; connecting the riser on the top, it is continued up to the highest radiators, and connected, as shown, to each radiator by only one connection; the distance from the riser to each radiator being as short as possible (the shorter the better) for this one-pipe connection. We will see by referring to table or list of openings in radiators, that for the same size radiators as those used on the two-pipe system, the openings will be one size larger, and the branch from the main riser to the radiator valve should not be less than the size called for in the tapping of the radiator. But in some cases where the lateral branch may have to extend some distance, I would use that part of the pipe even one size larger, as the steam must pass up to the radiator, and

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the condensation or water must pass down through the same pipe. The main steam riser in this case for the one-pipe system, as shown in Fig. 41, should also be about one size larger than the steam supply riser for the same amount of radiation on the two-pipe system. In all such cases, as shown in this plate, for the one-pipe system, I would recommend the use of a bulbhead tee at the point marked *B*, and also have the next tee above it one size larger than is called for by the following piece of pipe, as that is a point in the system where all the condensation from every inch of the pipe and also all the radiator surface must pass all the steam that supplies this section of the plant.

RADIATOR VALVES FOR THE ONE-PIPE SYSTEM.

The valves used on the one-pipe system to control the heat should be of a make having the largest possible opening, or a full clearance when open, in order to give as free a passage as possible to the flow of the steam to the radiator and the return of condensation.

ECCENTRIC REDUCING STEAM FITTINGS.

The straight or regular make of reduced steam fittings do very well in some places, and are much better than the fittings that are not reduced, as they make it unnecessary to use bushings in places where the size of the pipe is to be reduced; thereby saving the price of the bushing, and in all cases making a much better job, also reducing the liability of leaking. But there are many places in steam work where the *eccentric* reducing steam fittings make a very much more complete piece of work than the straight reduced fittings.

In Fig. 42 is shown a section of a main steam pipe reducing in size at each outlet taken off it. Having to make provision for the carrying away of the condensation which takes place in the pipe, it is pitched down away from the boiler, as shown. Therefore all the condensation which takes place in the entire length of this main line, and in some cases parts of its connections, must pass through the last piece of pipe on the line, where it then drops down and passes into the return pipe. It will be seen that, to take care of this condensation, the full opening in the different sizes of pipes as placed on such work are small enough, without being partly filled or choked in any way.

Referring to Fig. 42, we will notice that the first tee, on the line marked *A*, is one of the straight reduced fittings, and the second tee on this line is the regular pattern, having the same size openings on each end; and a bushing, marked *B*, is used in this tee for the purpose of reducing it for the next size pipe. It will be readily seen what happens when such fittings are used in a place of this kind.

The dotted lines at the bottom of each tee, and also extending above some distance in each piece of pipe, show the amount of water which always remains in the

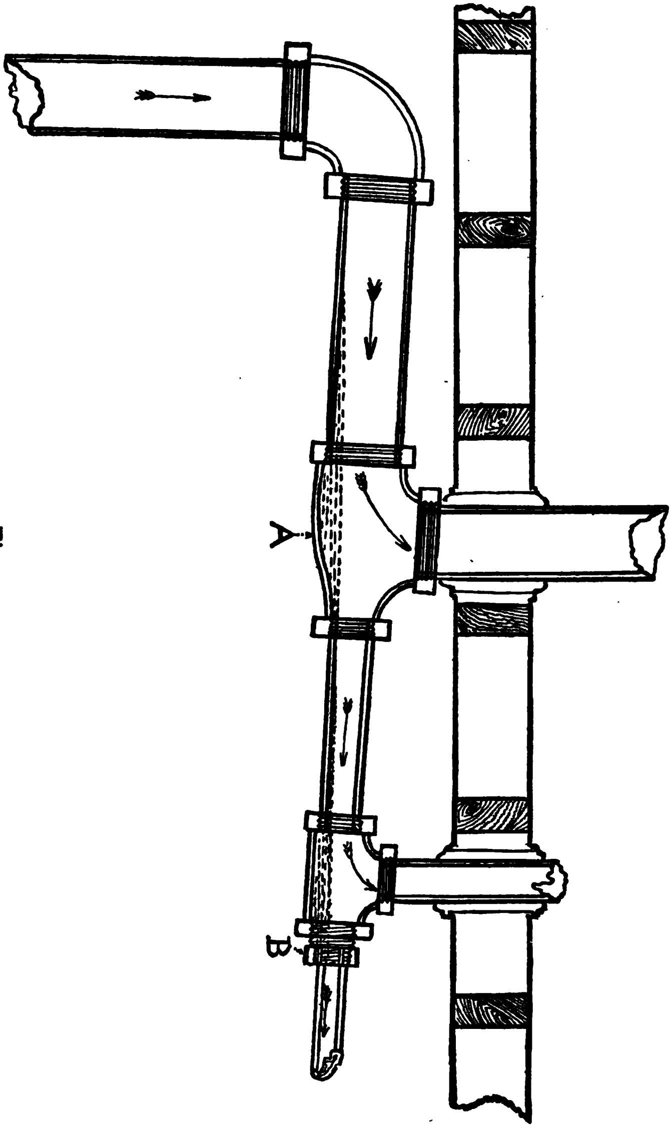

Fig. 42.

pipe, thereby to that extent reducing the capacity of the pipe; so the less the main line is pitched the more water will remain in them. It is not always possible or convenient to put in drips, whereby such water may be carried away, but even that would cost something to do.

In Fig. 43 is shown the same section of steam pipe with the eccentric reducing fittings used. It will be seen at once that this is much the best and neatest job, and without any additional cost. The first tee on this line, marked *C*, is an eccentric reducing tee, the small end, or opening, being tapped out on a level with the bottom of its opposite end, in this way giving a straight line to the pipe on the bottom side; while the difference in height of the different size pieces of pipe is all made on the top side. In this arrangement there will be no chance for water to remain in the pipes, leaving the entire capacity of the main for its work without the least obstruction. The second tee on this line of steam pipe, Fig. 43, may be the common, ordinary straight tee, as shown, but it would be better to use the same kind as the one shown at *C*. And even with the common tee we can still carry out the work by the use of the eccentric reducer, as shown at *D*. But we would also have to use a short nipple screwed into the end of the tee first, and then the reducer screwed on to the nipple. This, of course, adds to the expense over that of the properly reduced eccentric

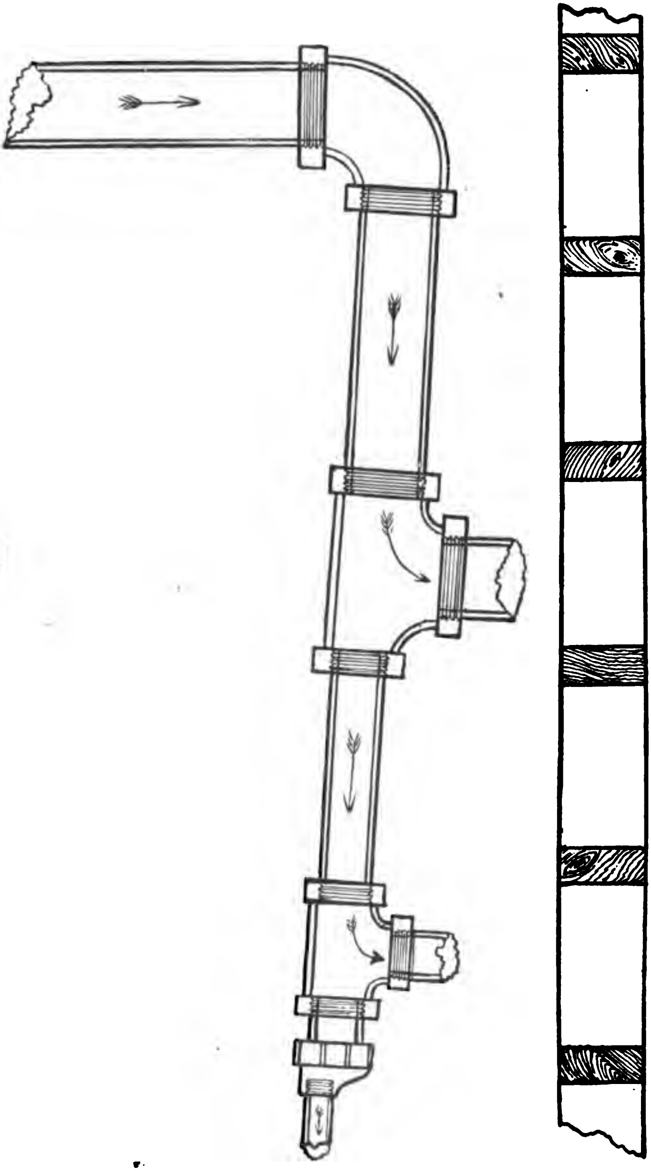

Fig. 43.

tee. The eccentric coupling or reducer is placed here to show how it can be utilized in such cases.

Fig. 44 shows the eccentric reducer. This fitting can be used to advantage in many places, especially where the eccentric reducing tees cannot be procured at short notice.

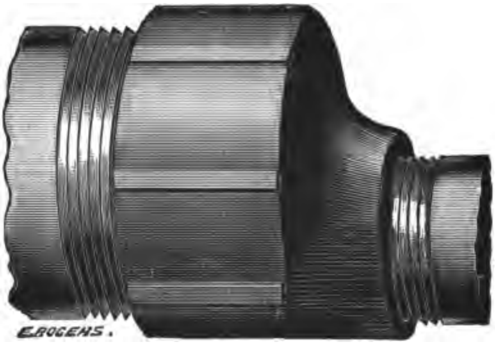

Fig. 44.

The eccentric reducers are now handled by nearly all the leading dealers in steam-fitters' supplies, while only a few of them are making the eccentric reducing tees, and then not a full assortment of sizes. We also have eccentric bushings now made by a few concerns, and it comes in handy in many places, and accomplishes the work much better than the ordinary straight bushing.

SPECIAL ADVICE TO THE MECHANIC.

There is one thing I would like to call the mechanic's special attention to, yes, and the business man, or any person who wishes to keep posted and be up to the times in his line of trade or business, and that is to use as much as possible the trade journals. They are the great educators, and any man who reads these papers and watches the sketches that appear from time to time in them is always the man with the most knowledge in his line. You will also notice that he is the most prosperous man. He is also financially better off if he is running a business of his own than the man who thinks he knows enough and has no time to read the trade journals. And again, the mechanic who is working for wages, and has a taste, as it might be called, for such reading matter as will give him more light on the work which he is engaged at—this is the employee that will soon receive the most wages of any man in the shop. And in all cases such a man will be found to be the foreman. There are many other advantages which the reading mechanic has over the other one. The one best posted, or having the most intelligence in regard to the different branches of his trade, will be sent to the finest work and will be pushed ahead. He will be sent to meet customers who are very particular and would like to talk to intelligent men, or men who could properly answer questions that such customers might ask them. The customer would feel more satisfied that the work contemplated would be satisfactory, and would have confidence in the fitter or plumber. There would be more satisfaction all round. The proprietor of the shop would have less trouble to collect his bill after the work was completed. The poor mechanic who neglects to take advantage of the great opportunity offered him through the first-class trade journals for a schooling in his line is simply to be pitied. He is the one who will be sent to such work as requires power of muscle. Heavy lifting when radiators arrive at the depot which are intended for some heating plant, and are to be carried up several flights of stairs, this man will be notified; while the intelligent mechanic who reads is busy at some nice, clean work, and cannot be spared.

I have seen mechanics who considered it an indication of ignorance in the trade to read trade journals for information. I know it to be just the opposite. It is always an indication of intelligence and ability to see a man or boy reading anything that will enlighten him on the things he wishes to know. And another thing, the man whose brow is adorned with academic laurels is not ashamed to be considered ignorant by reading the trade journals. His intelligence acquired at college tells him that, although he has taken special courses in his particular branch of trade or business, it will still be necessary for him to watch and read the different journals if he intends or wishes to be numbered among the successful ones.

I recommend the careful reading of the articles in the different trade journals to both the mechanic and business man and the apprentice, and the filing and preserving of them for the reason that persons in the journalistic business make a specialty of bringing before their readers such things that will be most interesting and instructive to them. The newspaper-man has the time or takes the time to look up such matters, because it is his business, while the man working at his trade or attending to his mercantile business cannot spare the time to go around and see for himself how things are being done elsewhere. I consider money spent for the subscription of the trade journals, in whatever line a person may be in, is the best investment he can make. The shrewd business man who has his eyes open for anything he can make a dollar on, although he may be stingy, pays for the trade papers and makes his investment pay. Such a man scrutinizes every inch of the journals, because he wants to know and see what other people and competitors are doing. He is also on the lookout for some new devices or novelties that may appear for the first time, that he may secure the agency for them for the territory in which he lives, because, as a rule, the first responsible applicant will get them, and the man who does not read at all simply gets left in such matters.

To those who are engaged in any capacity in hot-water heating, steam or gas fitting, I would respectfully recommend, as the best advice I can perhaps give, that they subscribe without further delay, if they have not already done so, for the leading journals in these lines, a few of which I would mention: *Heating and Ventilating, The Master Steam Fitter, Domestic Engineering, The Plumber's Trude Journal, The Architect and Builder, The Sanitary Engineer, The Metal Worker, The Sanitary Plumber, Scientific American* (Builder's Edition), and *The Manufacturer and Builder*, and for the best information on anything pertaining to gas *The Progressive Age.* There are other excellent journals representing these branches of trade, the names of which I do not remember at the present time.

UNDERGROUND STEAM WORK.

There is considerable steam work done throughout the country where the boiler to furnish the steam is located in a separate building or boiler-house built for the purpose, and located some distance from the building to be heated. I find and have constructed a large number of such plants, connected with churches, schoolhouses, colleges, and institutions of different kinds, and there are many points about such work that the fitter who has not had actual experience with such a piece of work should know before undertaking it. Fig. 45 shows a plant of this kind, and in laying out such a job there are many things to be considered in the very beginning, according to the situation.

Among other things the fitter should know is how

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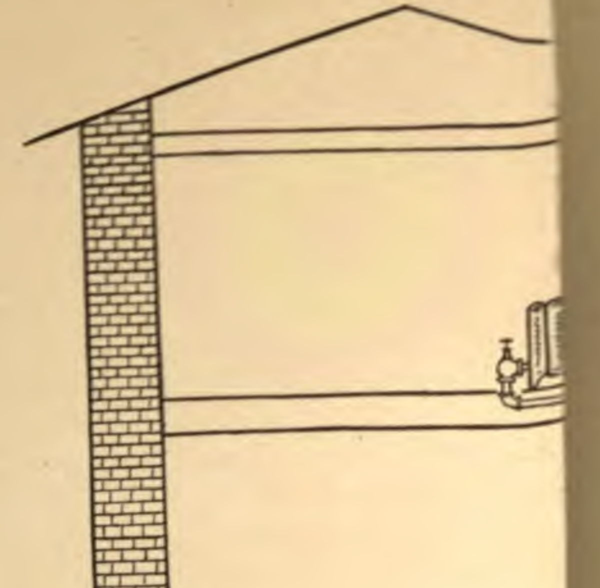

A

low down or how deep he should locate his boiler, or, in other words, how high up he can keep it, and at the same time have the plant work successfully in every particular. There may be rock in the location of the boiler, or it may be a wet place with no proper drainage to keep it dry, and therefore there might be something saved by not having to go down so deep. It is not a very nice looking thing to see a steam-supply pipe carried overhead or above the surface in such places, and, besides, it would have to be well protected from the weather, which, when put in such shape, would be very cumbersome and unsightly; consequently, where it is possible, the best plan in such cases is to carry the supply pipe underground.

A steam pipe carried underground for ordinary purposes does not have to be placed so very deep in the ground in order to be entirely safe against frost. We will suppose we have a job on hand, something like that shown in Fig. 45, and the distance between the boiler-house and the building to be heated is 50, 75, or 100 feet, and the cellar of the building to be heated is not very deep, say 7 or 8 feet, and to make it still worse, we must use some indirect radiation, which, of course, is located in the cellar. It will now be seen that we will have to be careful about the running of our pipes, and, of course, we will. The only thing necessary is to take the proper level of the ground and decide upon how deep we will lay our main pipe below the surface. That being settled, allowing for a reasonable fall or pitch toward the boiler, the next thing to do will be to find out the height the water will stand in our boiler, and where we are pinched for depth we will, of course, keep up as high as we possibly can. In this case we will allow 6 or 8 inches between the water line in the boiler and the bottom of the main steam pipe at its lowest point, or where it leaves the boiler-house. Therefore, we will have what might be called close work; and I know of a great many such jobs that work in the most satisfactory manner. We would first lay a terra-cotta pipe large enough to pass through it with ease whatever size steam main with its fittings that we concluded to use or was required to heat the building. The ditch carefully graded, with a little fall to the boiler-house, the terra-cotta pipe should then be laid, and each joint of it carefully cemented so that surface water could not enter it. And as all the steam necessary to heat the building must pass through one pipe from the boiler-house, and also all the condensation or return water must pass through the same pipe back to the boiler, and also taking into consideration the fact that we have very little fall to the pipe, we should make this main pipe a good size in order to do its work with ease. And having considered upon the size of this main pipe, the next thing that might be considered is the expansion of this long line of pipe, and especially because it is a large pipe, so that we will have to make our connections on each end in such a way that there will be room for this pipe to move or swing as it heats and cools.

In the building on the left-hand side of Fig. 45, which is to be heated, is shown a nest of indirect radiators located in the cellar, and on the second floor is shown one direct radiator. This is enough to illustrate the general principle that may be carried out in heating such a building from the boiler as located. That is, there may be as many direct or indirect, or any other kind of radiation used, and yet work successfully. The radiators in such a job may be connected also in any way that we may choose to connect them; that is, we may use the two-pipe system or the one-pipe, or any way that steam connections are made with any other plant.

In Fig. 45, *A* represents an indirect radiator, which will answer to illustrate how all indirect radiation is placed. Indirect radiation is, of course, the best system of heating that we can have, and when it is properly carried out, regardless of expense, it is all that we can desire. The same principle of indirect heating is carried out with hot water as that used for steam; the radiators being set in the same way. But the pipes are in some cases connected differently. In all indirect radiators it will be necessary to use air valves, and the best one to use is what is known to the trade as the "Breckenridge Automatic Valve." It is very simple and stands a long time without getting out of order. It will be noticed that the connections to the indirect nest shown in Fig. 45 have no valves on them, and that is because I do not approve of valves on either the supply or return pipes. There is a great deal more danger from having valves than from not having them, for the reason that where indirect radiators are used, registers are also used. The register is made to open and close, for the purpose of turning on and off the heat, as required. Therefore the only use that valves would be on the supply or return pipes of indirect nests is to shut off the steam or water for the purpose of repair. And that is done so seldom that, should it become necessary to use them, the valves would be worn out for want of use (as might be said), and then would not answer the purpose. There is always more or less wear and tear on the seat of the ordinary steam valve from it standing open while steam and water are passing through it, for the reason that the steam or whatever passes through it has a full chance to cut the seat, while if it were closed part of the time it would stand just that much longer; so I could never see any use in putting valves on indirect radiators, but I have had to put them on because they were specified.

THE DISADVANTAGES OF VALVES ON INDIRECT NESTS.

The use of valves on supply and return pipes of indirect radiators are not only of no benefit, but they are a great detriment to the general good results from the heating apparatus. In the first place, they are to a great extent an obstruction to the flow of either steam or water; they add to the already too many joints in the system. The stems of such valves are constantly leaking and blowing steam all over the cellar, and keeping the floor wet. Part of the steam finds its way up through the loose casing of the radiator, and in that way gets all through the house. Such valves are sometimes turned on or off by persons who mistake them for something else, and the first thing we know is that the nest has become filled with water, and then frozen solid; because when the steam was turned off, either by accident or intention, by persons who understood what they were about, or by persons who knew nothing about such things, they would be very apt to neglect to close the cold-air supply coming into the nest at the same time. I have seen more indirect radiators frozen and cracked due to the use of valves on them than from almost any other cause. If we have more heat than is wanted where we use the indirect radiator, all there is to do is to close the register, and if there is no circulation of air up through the radiator there will be very little loss of heat, as it will remain in the radiator and protect itself against freezing. And again, if we cannot have an automatic regulator on our indirect nest to operate the damper in the cold-air supply to the nest by its own temperature, we should not have any slide or arrangement for closing the supply of air. This is another matter that is forgotten with such heating. The damper in such cold-air supply pipes is often closed to shut off the supply of cold air, and it may be two or three days before it will be opened again. In the meantime the occupants of the house will have been suffering for more heat, and of course they could not get it when there is no cold air coming in to cause a circulation. Some persons use a slide in the cold-air box or in some part of the bottom of the casing to take their supply of air from the cellar in very cold weather, and stop off the outside supply entirely. That is a very bad thing to do. Cellar air should not be used in any case. I don't care how clean the cellar may be, the cleanliness of the cellar is not always the point in such matters. It often happens that where there is such an opening at the bottom of the indirect nest directly into the cellar, the hot air, in place of passing up into the room it is to heat, will do just the other thing, and pass down into the cellar that it is not to heat. And this is easily accounted for in the fact that it often happens the cellar is a much warmer place than the room up-stairs to be heated, and as the air in the cold room up-stairs is much heavier per cubic foot than that in the cellar, which is warmer, the cold air naturally falls and passes from the room to the cellar, and in this way there will be less heat sent up than if the entire cold-air box was left open from the outside atmosphere ; so that there is really nothing saved by taking the air from the cellar, but, on the other hand, there is often a great deal lost. The indirect system of heating is the best, because it not only gives us ventilation or a supply of fresh, new air at all times, but, as stated before, it costs a great deal more than the direct system; but it is worth more than the difference.

The reason why indirect heating costs more than the direct system is plain enough. In the first place, we will require more radiating surface or larger radiators to heat the same size rooms or house, because the indirect radiators have to contend with fresh cold air coming in from the outside, while the direct radiator has only to heat the air in the room where there is perhaps no ventilating stall. And again, the casing is to be furnished to place around the indirect nest, also a cold-air supply pipe or box, and to convey the heated air from the nest to the room it requires another tin pipe and also a register; and, of course, such work takes much more time as well as the extra materials than that required for direct heating. There is nothing better to use for casing-up indirect radiators than galvanized sheet-iron. The casing should be fitted close to the radiators on all sides, leaving a space above the top of the radiator and below the ceiling of about 14 inches, and a space between the bottom of the casing and bottom of the radiator of about 6 inches. The cold air should enter the indirect nest at the bottom, and opposite end to the outlet or hot-air channel on top, as shown in Fig. 45. This plan gives the air a proper chance to properly pass through the radiator sections and make a complete circulation through the nest.

THE VACUUM PRINCIPLE OF STEAM HEATING.

Another system of heating is what is called the vacuum principle. This is used in connection with the high-pressure supply or the exhaust steam supply, and its principal points consist in forming a vacuum in the system of pipes and radiators. A cylinder is located at the lowest point on the return main pipe, and this cylinder receives all the condensation or return water, which, by an automatic arrangement, is carried and delivered into the boiler again. The vacuum cylinder acts like a pump on the return system, having a tendency of pulling or drawing the water or air towards it. After the plant is completed and tested and everything ready to turn on the steam, the air is pumped out of the vacuum or receiving cylinder; then, being closed tight, it is all ready for its work. All steam jobs after they have been started up and once heated become to some extent a vacuum job, for the reason that to have a complete circulation of steam all the air would have to be expelled; and then if we had no air valve or leaks of any kind in the pipe system there would be a partial vacuum formed.

SPECIFICATIONS OF STEAM WORK—HOW TO FIGURE ON THEM AND AVOID MISTAKES.

In figuring on steam or hot-water work from plans and specifications furnished by the architect, there should be no trouble or chance for mistakes on the part of the fitter, providing the plans and specifications are complete, for the reason that there is nothing else for the fitter to do in such a case but to figure up the cost of the necessary material, which is already laid out for him, having nothing to do but to put the price to it, and of course guess on the time it would take to do the work, also cost of freight, cartage, excavating, and such matters as these, which come easy enough by experience. If the specifications are complete they will show the location of the boiler and radiators, also the lines and sizes of all supply and return pipes; it may or may not specify the particular make of radiator or boiler, but it would give the capacity, the number of feet in each radiator for the different rooms or halls, and also state the entire amount of radiating surface. And to make the specifying of the boiler as complete as that of the radiators, it appears to me that the architect should call for a specified amount of fire or heating surface in the boiler, the same way that heating surface is specified in the horizontal tubular boiler, and it would also be well to call for the amount of grate surface. This could all be done and yet not specify any particular boiler. If the specifications were carried out in this way there could scarcely be a mistake made, having a complete specification to figure on. The safest and proper thing to do is to simply copy off the specifications and make up the estimate from it. First, take the boiler, its size and capacity being specified, put down one boiler just as it is stated in the specifications, and if it should be necessary to have the boilermaker give us his price on the boiler, we should furnish him with an exact copy of all the dimensions of the boiler just as it is stated in the specifications. In that way there can be no mistake on our part. When we get the best price on the boiler, place it on the estimate book opposite boiler. In the same specification we next take the radiation surface and put down the entire number of feet, putting the best price to this, and carrying out the net cost opposite radiators. Should there be radiating surface of different prices, such as part direct and part indirect, or any other kind, keep each separate and carry out its own price by itself. After having the radiating surface all figured, we should then find out the number of radiators, and this will give us the number of valves we want, putting down each size and kind just as specified, keeping each size separated, and the best net price marked opposite each as before. This will also remind us of the air valves on each radiator, so they go down as the others, and having a plan of the pipe system we can measure off each size, going all over the plan, and marking down the largest size first. After we have each piece of the largest size we then add them all together, and put down the number of feet in them all; then taking the next largest size in the same way until we have all the sizes. This is better than to mark the pipe down just as it comes in the line we start at, as it is more easy to get mixed up in the different sizes. Take the number and size of fittings in the same way. First begin at the boiler, and count the number of the largest size elbows, and where a fitting is reduced always call it by the largest opening, as that is the way the manufacturers sell it, no matter how small some of its openings may be. For instance, if we have a tee 2 inches on one end and 1 inch on the other end and a 1½-inch outlet, that would cost as much as a straight 2-inch tee. Therefore in making the estimate of cost simply take the largest opening. After we have counted how many of the largest ells there are to be used, we put them down and put the price to them ; then we go on with the next largest size elbow in the same manner until we finish with all sizes of elbows. Next come the tees, and the same plan is carried out for them, taking the largest size first, and so on to the end.

Where any special thing is specified, such as check valves in the return pipes, or globe or gate valves on the main supply or returns, we are reminded of this by the specification, and therefore have simply to put the price to them. Having carefully gone over the plans and specifications in this way, we will have formed some idea as to the amount of time such a job will take, and therefore give a closer guess at that. Having carefully gone over every item of expense, the cartage, the freight, the bronzing, the painting, putting down the net cost of everything as nearly as possible, it would only be necessary to settle on how much profit we would want on the work, or what percentage we would undertake such a piece of work for; or, again, in some cases, how much we thought the customer would pay where we had the inside track.

THE OVERHEAD SUPPLY SYSTEM OF STEAM HEATING.

What I consider one of the best systems of low-pressure steam heating for large buildings of any kind is the overhead supply system.

The general principle of this arrangement is shown in Fig. 46, having the boiler located in the cellar or basement, like any other low-pressure system. But the difference is in the way all radiators are supplied with steam; and that is, in place of taking off branches from the main supply as it rises from the boiler, there are no branches taken off until the main pipe has been carried to a point above the highest radiator, then turning in as many directions as the building requires, with an incline down from the point as marked at *A* in Fig. 46, and connecting to the different lines, as shown in the plan. Both the steam and the condensation travel in the same direction, except where we connect supply pipes to the bottom of radiators, and that makes very little difference; but they may be connected at top for supply and at bottom for return, if desired. In such a plant as

shown in Fig. 46, with the main rising steam pipe carried so as to have little condensation, we will have almost a perfect job. It appears to me that this is the true principle of heating by low-pressure steam, for the reason that the condensation falls away quickly from wherever it is formed and to where it is wanted at the boiler again, and in all cases getting out of the way of the steam. In such an apparatus there can be no such a thing as noise in the pipes, which is caused by the filling of some of the pipes with water where steam must travel.

NOISE IN STEAM PIPES, AND HOW IT IS CAUSED.

It might be well to state right here what the true cause of such noise is. We all know very well that the cracking and snapping noise heard in some steam pipes is a most disagreeable thing to listen to, and more than once I have heard of persons who have abandoned the use of steam for heating purposes on account of the noise in the pipes, and who for ever afterwards were against the use of steam and in favor of any other system. Such people are not always to blame for such actions.

There is not the slightest reason for this disagreeable noise, and where it exists there also exists a bad job. In the first place, it is an indication that the work has not been properly done; and if this is not the case, it is then a fact that the people who are using such an apparatus do not understand it, and have some one or more of the valves turned wrong. But, as a rule, the true cause is in the work not having been done properly. In such cases or places where the cracking noise occurs, it will be found that some of the steam pipes are not properly pitched; that is, part of a piece of pipe may pitch downward and without a relief rise up again, and in this way leave a depression or trap in the line of steam pipe, and as it is a low point the condensation will lodge there and at times stop the flow of steam.

NOW THIS IS WHERE THE NOISE IS, AND ALSO HOW IT TAKES PLACE.

The noise is caused on account of a vacuum being formed in this water trap, or the condensation which has formed in the depression of the steam pipe. The way the vacuum is formed in the water is this: The water, being much colder than the steam and of course very much heavier, requires some force of the steam to push its way through this water; and as is noticed, the most noise is generally when the steam is first turned on and for a little while afterward, when sometimes such noise will cease. Now, this is because there is a pressure of steam rising from the boiler, and the pipes, being cold, condense water very rapidly, and soon form enough to fill up such pockets as described. The steam comes along and has enough pressure or power to force its way partly through the water, and when right in the water the steam has made room for itself, or, in other words, it is hemmed in and has water on both sides of it. Now, this amount of steam, whatever it may be, condenses in the very middle of the water, and so quickly that a vacuum is formed in the space formerly occupied by the hemmed-in steam. Therefore this vacuum must be filled, and the water from both sides of the low point in the trap or depression come together with the force of the atmosphere, which is 15 pounds to the square inch, hence the noise when they meet. There is no difference between this kind of noise and swinging two hammers and striking them together, one meeting the other, only the water comes together with more force than that exerted by the hammers. This explanation also answers for the noise which we hear when steam is forced into water. Going back again to Fig. 46, it might be noticed that we can, like the other systems, use the one or the two pipe system, and also connect the pipes in any way that we desire; that is, we can connect the supply at one end and the return at the other, or we may connect both the supply and return on the same end, or enter the steam at top of radiator and take out the return at the bottom, or either the same end that the steam enters or the opposite end. In Fig. 46 we show three lines coming down from main supply, *A*, *B*, and *C*. *A* is dropped straight down to the cellar and returns direct to the boiler, as shown by the arrows, and branches are taken off between the flow, or under the floor, for each radiator on its line, and a return pipe is carried down also, which connects to each radiator, as shown, and finally ends in the return pipe below the water line, which gives it a complete circuit. On line *B*, as will be noticed in Fig. 46, we have two rows of radiators, one on each side of the supply pipe on each floor, and one line of radiators is connected at both ends, while the radiators on the other side are connected at only one end; this may be done and both work satisfactorily. I wish to call special attention to the way each branch is taken off the supply, and also the main return; that is, each connection has a separate fitting or tee for itself. This is always the best way, and particularly with the return pipe connections. These lines, as may be noticed, are also carried down and connected below the water line. The main supply pipe from the boiler is dripped just the same as the other, so that any condensation forming in it will find its way to the return pipe, and the connections are made, as shown, for the purpose of allowing the long vertical line to swing up and down as it expands and contracts.

Line *C*, in Fig. 46, shows the one-pipe system, which may be carried out to perfection with this overhead system, connecting the pipes as shown. Where there are long lateral branches, have the pipe a good size, and it will be found that this will give the best possible results. I rather prefer the one-pipe system where we have an overhead supply, as shown in Fig. 46. Of course the fitter must be careful about his valves, getting for all one-pipe work the largest opening valve he can, with the radiators tapped large enough, and the pipes of good size, having as much pitch as can conveniently be had.

STEAM AND HOT-WATER BOILERS FOR DOMESTIC HEATING.

Before closing the subject on heating I would like to call attention to the boiler.

I have tried to show the necessity of having all the piping in hot-water and steam heating plants done in the best possible manner, in order to attain the best and most economical results, and in a brief way I will try to do the same thing in regard to the boiler. To carry out a first-class piece of hot-water or steam work complete, it will be necessary to have a first-class boiler, one that will do its part of the work in the same satisfactory and economical way that may be had from a strictly good piece of pipe work. The fitter who has not had much experience will meet with considerable trouble on this point, for the reason that there are so many TIN-PANS and HUMBUGS on the market called boilers, and are sold by persons who should and could be prosecuted for not only misrepresentation, but for endangering the lives of innocent people who live in houses where such things are installed. Remember, the common tea-kettle will do to heat water or make steam, but it takes considerable coal or fuel to do the work on that principle in proportion to the quantity of water heated or the amount of steam generated, and it is ten times worse with a poorly-constructed steam or hot-water boiler. As a rule, I have found that boiler-makers of very limited experience practically would not only rate their boilers very much higher than old reliable and experienced concerns, but are willing to give the strongest kind of guarantees that their boilers will do what they claim, and this is one of the reasons why so many so-called boilers are sold. This reminds me of a case of this kind where I was to some extent the victim myself. I had a customer who wanted his place heated by steam, and he gave me the preference of the work even at a higher price than others; but he had his mind made up in regard to the boiler he wanted used, and it happened to be one that I had never heard of until he gave me the name of it, and told me where it was made. I tried very hard to have him take one that I had had experience with and could recommend in the highest terms; but it was no use, my customer would not change his mind in regard to the boiler, so there was nothing left for me to do but to either get that boiler or let some one else do the work, and I concluded to go to where the boiler was made and see what it was, and also order one for my customer. I arrived at the boiler-works and was introduced to the general manager, who gave me prices and capacities of the boilers. I had about 900 feet of radiating surface to heat, and I concluded to buy a boiler that would carry with ease 1,000 feet. While in the works I examined a boiler which was being put together, and I asked the superintendent or general manager what the size of that one was, and also its capacity. He said: "That is our No. 6, and that size will carry from 1,200 to 1,450 square feet of radiating surface, and with ease." And according to the rating in his catalogue, the No. 5 was too large for my customer's job.

But after looking at the boiler I concluded that there must be something wrong in regard to the rating which they gave me, and I asked another question: "How much heating surface have you in this No. 6 boiler?" And the answer was, "I don't know; that is something we have not found out yet." Then I asked: "How do you know how much that boiler will heat without knowing the amount of good, available heating or fire surface in it?" "Well," said the manager of the boiler-works, "we know what it will do from experience. We have that size boiler carrying 1,600 feet of radiating surface, and we can't keep down the steam." I afterward discovered that the one they were building in the shop at the time was the first of that size they had ever made.

I concluded to ask no more questions in regard to the boilers there, and gave them orders to make and ship to my customer a No. 6 boiler, to heat the 900 feet of surface. It came and was set up, and connected to what I call a very nice job of steam-piping, and one the best fitter in the land would not be ashamed of. We started the fire; the outside atmosphere at the time was about 55 degrees, and to get steam to circulate through the last radiator it was necessary to make the boiler red hot, and the heat from the boiler nearly set fire to the building. With the 900 feet of radiating surface open to the boiler, the steam gauge never showed even a half-pound pressure, and in order to raise the pressure of the steam to one pound we had to close off one-third of the radiators.

It then became necessary for me to explain the reason why that boiler would not do its work satisfactorily, and after satisfying my mind that the drafts in the chimney were good and all right, I then measured up the heating surface in the boiler. All that I could consider fire surface was about 95 square feet, and that amount multiplied by 6 would give us just 570, which would be the proper capacity for such a boiler; and this was proved before I had measured the boiler surface by the closing of about one-third the 900 feet of radiating surface. I then measured the grate surface, and found it was 5 square feet, which was just twice the size it should be for the 95 feet of boiler surface. This was surely a case of misrepresentation, and also the most extravagant thing in fuel that ever came under my observation.

Another thing, neither the guarantee nor the goods of such concerns are worth one cent. The case cited was one of ignorance, not done with intention of cheating any person, and such cases are really the most dangerous. There are many things to be considered in selecting a boiler, and it is not enough to have a boiler-maker tell us that he will guarantee his boiler to do so and so; he should first guarantee that the boiler has a certain number of square feet of good, clean, available fire surface and also a certain amount of grate surface. We can tell then ourselves whether we are going to get a boiler that is extravagant in fuel or one that will be most economical in that respect. In this way we can tell just what his boiler is worth, and whether we are getting a bargain or not, also what amount of surface we ourselves would risk such a boiler with. The fitter does not thoroughly understand his business who does not know when a boiler is properly and economically proportioned. Although he does not make the boiler, he should still know as much about it as the boiler-maker in regard to its principles in every respect.

A type of boiler that we cannot be deceived in in regard to its capacity or actual fire surface is shown in Fig. 47, and is manufactured by Gorton & Lidgerwood Co., 96 Liberty Street, New York City. As will be noticed, this boiler is made in two parts, a lower and upper section, and every inch on the inside of the jacket is actual fire surface, and may be counted as such in figuring up its capacity. There are many types of boilers that have large surfaces of some sort, but on account of faulty construction half, and in some cases even more, of their size or so-called fire surface is worthless, and where the fitter counts on such dead fire surface, as it really is and should be called, to do some certain

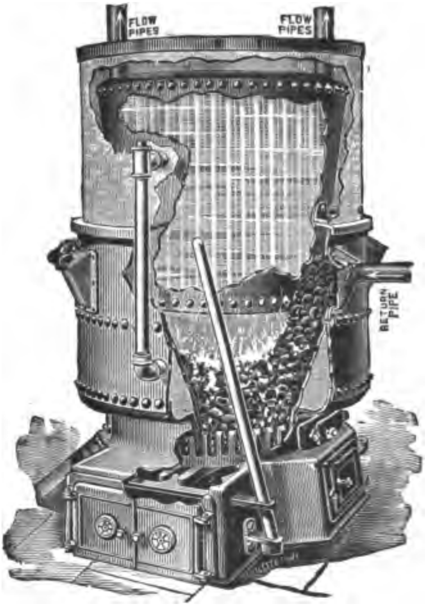


Fig. 47.

amount of work anywhere near its rated capacity, he will be counting on something that he has not got, or never will have as long as he uses such a boiler. Besides, he is not doing right by his customer, who fully trusted him to do a first-class job. Therefore, it is a very important thing for the fitter in selecting a boiler to know that the rated capacity of the boiler he is about to purchase is based on *bona fide*, clear, actual fire surface, each inch of which does its full share of the work. The Gorton boiler, as shown in Fig. 47, besides being an honest rated type of boiler, is admirably adapted for house warming by either hot water or steam.

This boiler, being made of heavy wrought iron or steel, will stand very heavy pressure, and we may never look for a leak in this kind of boiler due to pressure. The upper section of this boiler is hung over the fire, with lugs projecting from it and resting on a ring, which also forms a resting place for the upper part of the jacket. The upper section contains as many vertical tubes as its size will admit. They are of proper size, and, being placed close together, cut up the water space, so that there is no large body of water at any point in it which the fire does not act upon. Having vertical tubes, as shown in Fig. 47, makes it easy to clean. It being in two sections, makes it practicable to get one of large capacity in through the ordinary cellar door, an important matter that must be considered for the heating of the average building. This is a boiler that will heat water rapidly, as the water's movement is all vertical in the boiler (also any boiler constructed on the true principles for heating water). It is also the best principle for generating steam. In Fig. 48 is shown the same Gorton boiler, with its trimmings on, as used for steam. The only difference between Fig. 47 and Fig. 48 is in the tapping or outlet; those on the boiler used for hot-water heating being larger than when used for steam work.

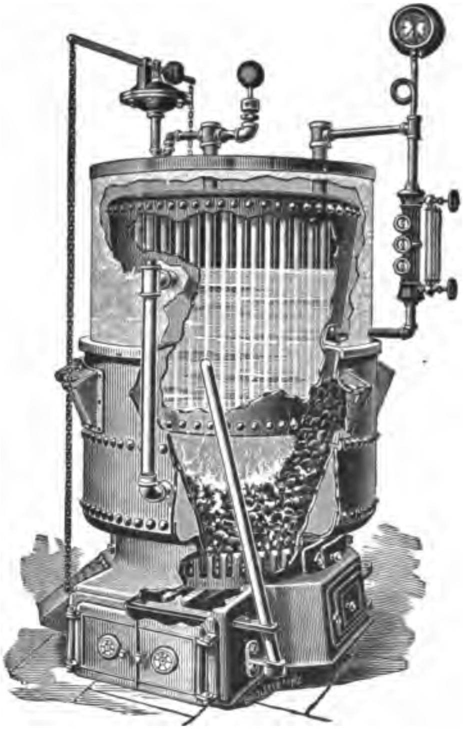


Fig. 48.

CAST-IRON BOILERS FOR HOT-WATER AND STEAM HEATING.

A cast-iron boiler that may be relied upon for full power of its rated capacity is shown in Fig. 49, known as the "Gurney Bright Idea" Water-Tube Heater, and manufactured by Gurney Heater Mfg. Co., 163 Franklin Street, Boston, Mass. The entire fire surface might be direct, getting the full benefits of the products of combustion, while at the same time deflecting it in such a way that only a small portion of the heat is lost compared with other makes. The ingenious arrangement of the tubes in this boiler makes it possible to get a very large amount of live fire surface in a comparatively small space. The tubes are made in loop-shape, and are set in a staggered position, so that it would be impossible

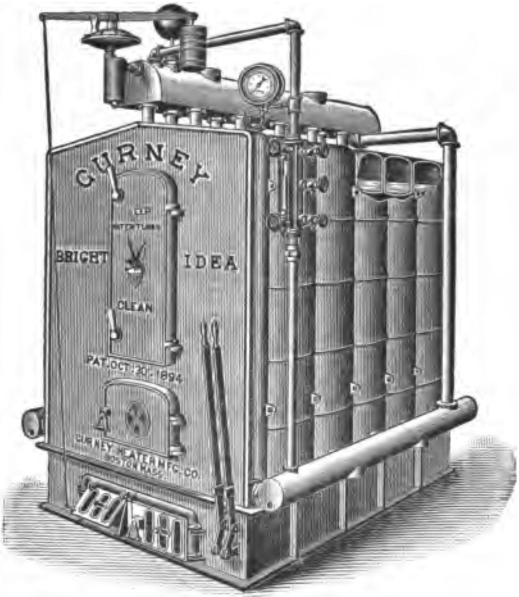


Fig. 49.

for the flames or products of combustion to pass without coming in contact with them. Another good point in the way these tubes are set is in their being tipped over, or set a little slanting. This gives the fire a chance to pass between the opening of the loops as well as around their top and bottom sides. And again, the tubes, being loop-shape, a rapid circulation of water is produced through them. The tubes being conical in shape on their upper sides, no chance is left for ashes or dust to lodge thereon and detract from the heating power; and hence I say that this boiler's actual heating surface is as represented. This boiler, the "Bright Idea," as shown in Fig. 49, is made in sections, so that it can be handled with ease and placed in any cellar through any ordinary door. It is also fitted with the latest approved shaking-grate, and is guaranteed by a concern whose guarantee means something.

Another type of cast-iron hot-water heater is shown in Fig. 50, and is made by the same company. It is called the "Gurney Hot-Water Heater, 300 Series." This is a heater that is not only quite famliar to the heating trade, but to the general public both in the United States and Canada, as it is one of the pioneers in the line of hot-water heating boilers; and though its popularity, even after many years of actual work, has many imitators of its principles, yet it stands first among them all. This makes an excellent heater for small dwelling houses, and is also one of the very best for greenhouse heating. It is also of the sectional type, and, as shown, one section is placed above another, so that its capacity can be made more or less without changing its diameter. Both the draft of the fire and the movement of the water in this boiler are upward, having their outlets at the top, thus getting an easy and quick circulation.

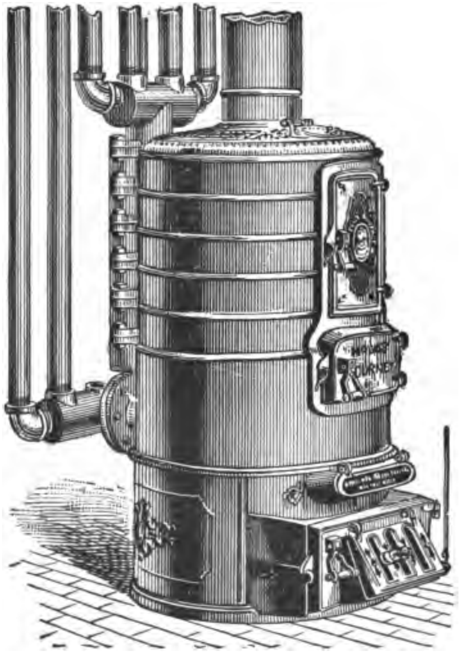


Fig. 50.

CAST-IRON BOILERS FOR STEAM HEATING.

In Fig. 51 is shown one of the latest improved cast-iron boilers, specially constructed for steam heating. This is also manufactured by the Gurney Heater Co., of Boston, Mass., and in it is embodied the loop-tube, as used and described in Fig. 49, thus getting large and effective surface economically and without return flues.

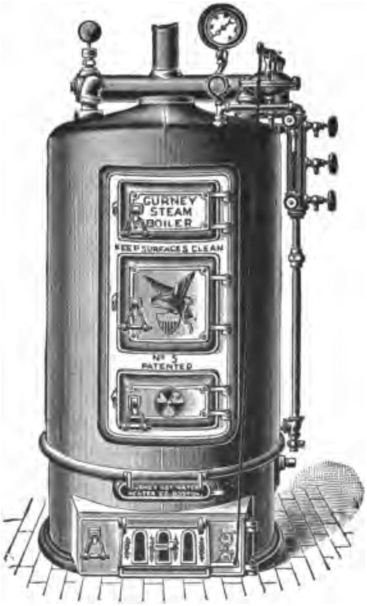


Fig. 51.

This boiler is round in form, and the body is made in two parts and held together by bolts, and stands on the base, making only three pieces to handle. The two halves are connected together at top by a special cast manifold, as shown in cut, from which the steam supply is taken, and at the bottom each half is connected for the return water in the same way. This is a powerful and rapid heater, and will stand very high pressure, as it is constructed on the high-pressure principle.

CARE OF THE HEATING APPARATUS—IT SHOULD BE KEPT PERFECTLY CLEAN ALL SUMMER WHEN NOT IN USE, AS WELL AS IN WINTER WHILE BEING USED.

There will be great economy to the householder in two ways if these instructions are properly carried out. First, to keep the heating apparatus perfectly clean while being used, we not only save largely in the amount of fuel we use, but also get a much better heat. And to have it perfectly clean all summer, or while it is not in use, we save, by preventing rust and destruction of its several parts. It makes no difference what kind of heating apparatus we may have to heat our house, whether it be a hot-air furnace, a steam or hot-water heater, we will find much better results, and also save greatly in expense for repairs by having the apparatus cleaned in the early part of the summer; and not only because it protects and preserves the apparatus, but because it is good from a sanitary point of view. Just as soon as we are satisfied in the latter part of spring or the early part of summer that the heating apparatus will not be required until the next season, and before the heater is really cold, then is the proper time to have it cleaned and put in order for the next fall.

DAMAGE DONE TO PIPES IN SUMMER.

There is often more damage done to furnaces and smoke pipes of any kind of heating apparatus in summer time, when not in use, than is caused by the general wear and tear during winter with the hardest kind of usage. This may appear strange, to think that anything should wear out sooner by not being used; but such is the case in regard to several parts of any heating apparatus. Soot and ashes do great harm when allowed to remain long enough in the flues, pipes, or tubes if the apparatus is allowed to become wet from the air in passing through without any fire. There is no arrangement for heating a house with fuel that does not accumulate in it soot, and most of them have soot, ashes, and dust. Soot and ashes do no particular harm in regard to corroding the iron or material on which they may lie while in a perfectly dry state, which they would be when in use on account of the fire; but just as soon as the soot and ashes become wet they form into a paste, and have a cutting effect, and eat away the iron the same as a very strong solution of acid.

KEEP THE HEATER CLOSED IN SUMMER.

After all the parts of the heater are thoroughly cleaned, having removed all soot, ashes, and dust from the smoke pipe, close up all the doors and openings of whatever kind on the heater, so that the air will not circulate through the pipes and keep them wet, which is the cause of rust; moist or damp air surrounding iron is more destructive and does more damage than if the iron was entirely submerged in water. The exterior castings should then get a coat of asphalt varnish, which will protect them from the inside atmosphere. If this is done well, and at the right time, there will be very little repairs required on the heating apparatus for many years. And if we neglect to clean our heater until it is required for use in the fall, we will find it necessary to renew some part rusted or corroded through during the summer which was sound and in good order in the spring.

THE STEAM-HEATING APPARATUS.

If the system we use to heat our house is a low-pressure steam-heating apparatus, we should know what is best to do with it after we are through using it for the winter. Very few people appear to know whether it is best to let the water remain in the boiler and pipes all summer or draw the water off and let it stand empty until required for use in the fall again. As I have mentioned above, iron appears to last longer entirely submerged in water than when surrounded by damp air. And this is the reason why it is considered better to let the water remain in the boiler and pipes all summer. If the boiler and pipes could be drained perfectly dry while the boiler was still warm, so that no moisture could remain inside of them, there would be less damage from rust or corrosion than in any other way. But there is less chance of having this properly done by either the people of the house or some steam fitter who has the work in hand. Consequently the next best thing to do is to let the water remain in the boiler and pipes all summer. It is well to draw off the old water, which may have some sediment in it, and then fill up the boiler and pipes again with fresh water, to remain there all summer.

THE HOT-WATER HEATER.

The same general instructions may be carried out for the hot-water heating apparatus as given for the steam heater in regard to how it should be cleaned and left for the summer. In cases where the water is left in the boiler and pipes and where they have an automatic supply valve, that valve should be closed, so that the water could not overflow or continue to run during the summer. Where the radiators have air valves which are operated by a key, so that they cannot be opened accidentally or by children, it is best to let the water remain in all the radiators throughout the system. But if the radiators have the common air-cock, which can be turned by the fingers, in that case it would be better to draw the water from the radiators, allowing it to remain only in the boiler alone, as children might open the valve, which would result in doing damage by the wetting of carpets and ceilings.

STEAM AND HOT-WATER RADIATORS—THE DIRECT INDIRECT RADIATOR.

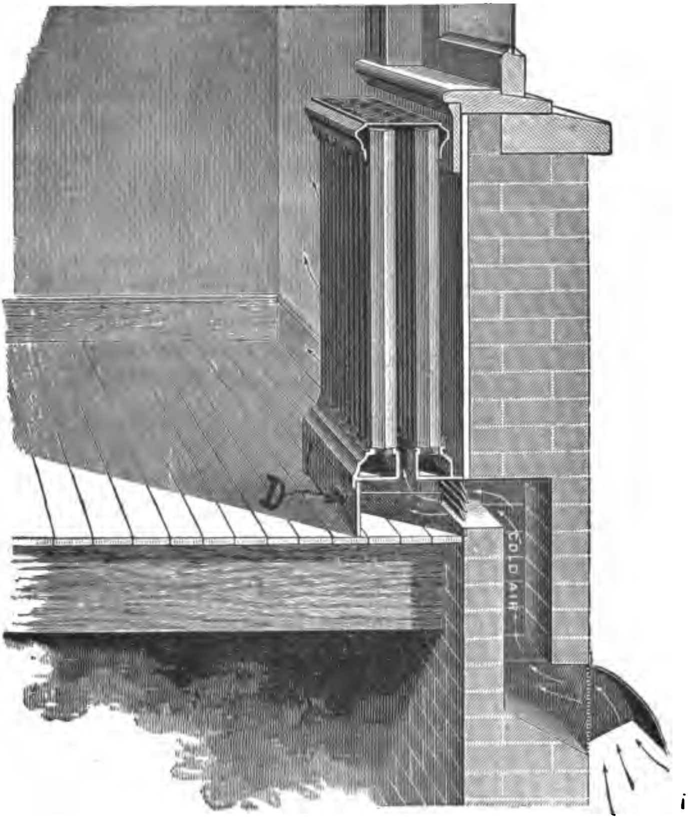


Fig. 52.

In Fig. 52 is shown the general principle of setting the direct indirect radiator. There are radiators of nearly every make which have a special closed base when used for this purpose, although any radiator will answer for the direct indirect purpose by closing the ends and front of the base, so that the cold air brought in from behind, as shown, will not pass directly through the bottom of the radiator and into the room, but up and over the heating surface of the radiator and then into the room. The supply of cold air may be regulated—that is, opened and closed as desired—by operating the damper marked *D*, as stated before. This is a cheap and good way of getting both heat and ventilation, without taking up any extra room in the cellar, which must be done where all indirect radiation is used.

GREAT DIFFERENCES IN RADIATORS.

The proper selection of radiators is a very important matter for the fitter to consider, as well as the selection of a boiler. All the radiators in the market are not alike. Some manufacturers of radiators seem to think that the essential point is to get as much outside surface as possible in a given space, or in the least number of pounds of iron, for the reason that they sell their radiators per square foot of surface; this is all right for the radiator man, but not always for the fitter. Radiators are poorly, extravagantly, and impracticably constructed as well as many types of boilers, and the essential points in the best kind of radiator are something that the fitter should know, as well as any other point in the whole arrangement of a steam or hot-water plant.

HOW ARE WE TO KNOW A PROPERLY CONSTRUCTED RADIATOR?

In the first place, we will have to use considerable good judgment of our own in making such a selection, and not depend on what every person who makes or sells radiators tells us. The very same trouble comes in here, as the fitter is apt to be confounded and misled in listening to the representatives of different boilers, each one claiming their own very much better than any other; therefore, it is actually necessary for the fitter to know himself what constitutes a good radiator. The radiator for water heating might be considered on the same principle as a boiler. We know that the best constructed boiler to do effective and quick work must have its water space cut up into small parts; that is, not too large a body of water at any point or place in it, so that the fire which is to heat the water in the boiler will act quicker on the water, and also more of it, than could be done where the water in the boiler is in large bodies, and less cut up.

This is the very thing that we want in a radiator. The only difference between the boiler and the radiator in this respect is, that the air in the room to be heated acts upon the surface of the radiator, having the tendency of cooling the water in it; while the fire or fuel in the boiler acts upon the tubes or heating surface of it, and having the tendency of heating the water. It will now be seen that hot-water radiators should not hold very large bodies of water per square foot of radiating surface, for the reason stated; and the best and most economical radiators do not hold more than from 13 to 14 gallons of water per 100 square feet of radiating surface in them. Radiators proportioned in this way will do better work than radiators which hold more water per square foot. Another matter or point to be looked at in regard to the radiator is its construction as to the way in which the air circulates with freedom over every inch of its surface. The entire surface of radiators cannot be counted as heating surface, unless there is sufficient room or air passages in them to allow the air to freely circulate over every inch of its surface. If we place a radiator having a high temperature in a box, it would throw out little or no heat; for the reason that the air cannot come in contact with it to become heated. To some extent this is the same thing with many makes of radiators; they are simply boxes, and the outside surface only of such is actual heating surface. It is well to consider how the joints of radiators are made, in order that there may be no leaks, and it is very well to consider the style or appearance of it, as direct radiators of the most artistic designs are eyesores to most people in a dwelling-house.

A RULE TO GO BY.

A radiator that is strictly first-class in every point of view for hot-water heating is always the very best kind for steam heating also. All hot water radiators will answer for steam-heating work, but all steam radiators will not do for hot-water work; for this reason, that the water radiator must be connected to both top and bottom—that is, the loops must have a water-way from one to the other, on the upper end as well as the bottom end of each loop, so that the water can form a circulation, and also because the air must be taken out of the top; while in the case of the steam radiator, the air might be taken from the lower part of a radiator. It will also heat without connecting the tops of the different loops together by openings, although we get a quicker circulation of the steam when they are made on the water radiator plan.

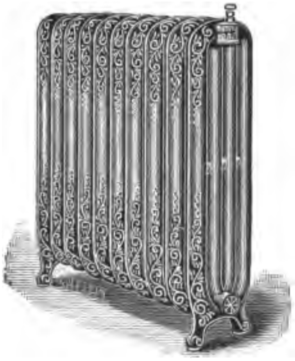


Fig. 53.

THE HARVARD RADIATOR.

A radiator that I can recommend as having all the good points and will fill the bill is shown in Fig. 53; it is called the Harvard, and is the latest design made by the Gurney Heater Company, No. 163 Franklin Street, Boston, Mass. It will be noticed in looking at the cut that the bottom of each loop is in circular form, so that there is not only plenty of room for air to get under the radiator, but its shape is such that there is the least possible obstruction to the movement of the air as it ascends to be heated.

THE LAWLER AUTOMATIC HOT-WATER DAMPER REGULATOR.

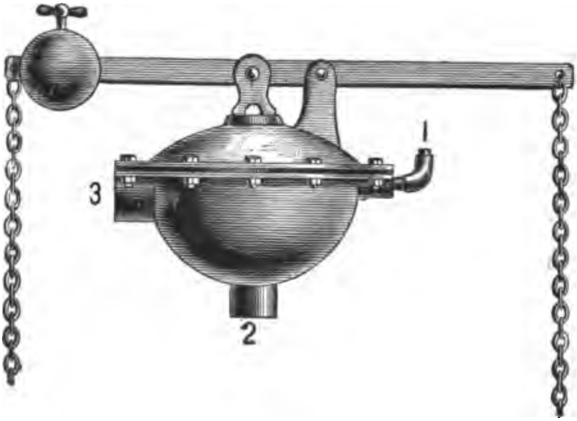


Fig. 54.

The above cut represents the Lawler Hot-Water Regulator, which will operate the draft-doors of a hot-water heating apparatus at any temperature of the water that may be desired, from about 120 degrees up.

In mild weather it will hold the water at a low temperature, and in cold weather it will allow the highest possible temperature of water to be carried in the heating apparatus without boiling over.

It is compact, neat, simple, durable, easily applied, and nothing about it to get out of order. It is nine inches in diameter, and its outlets to connect with flow and return pipes are for one-inch pipe.

This regulator is manufactured by the Lawler Waterfeed and Damper Regulator Co., No. 189 Mercer Street, New York City. In Fig. 55 is shown a sectional cut of the Lawler Hot-water Damper Regulator, whereby the principle upon which it works may be easily understood.

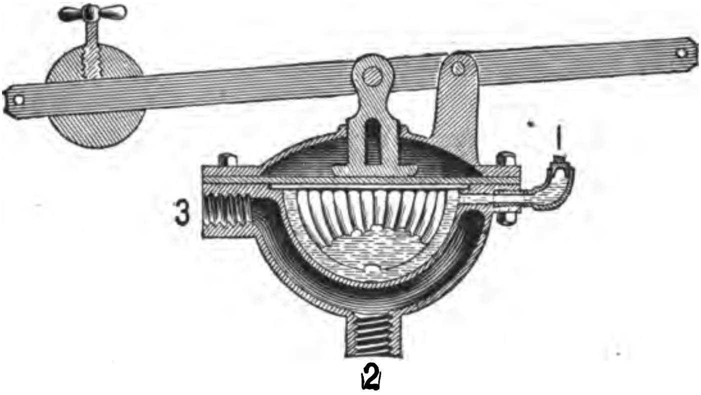


Fig. 55.

The lower section or body of the regulator is cored out and cast in one piece, leaving a water space between its inner and outer walls. The water from the boiler or heating apparatus is carried through this cored-out space by connecting the flow pipe into outlet 3, and also connecting a one-inch pipe to the regulator at bottom, outlet 2, and carried down to bottom of boiler, thus forming a circulation of the water through the regulator. The inner wall is corrugated for the purpose of getting as much heating surface as possible in a small space. Below the diaphragm, in the boiling or expanding chamber, is placed a sheet brass air chamber, being air-tight at top and open at the bottom. This air chamber is also corrugated in shape, for the purpose of getting large surface. After the diaphragm and cover are put on and made tight, the boiling chamber is then filled with either water or alcohol, through the opening at No. 1 ; the plug being replaced, it is now hermetically sealed and ready for operation. The liquid to be boiled by the temperature of the water can only enter a short distance up into the corrugated air chamber, and the space which it occupies between the outer wall of the air chamber and inner wall of the body is quite thin, consequently the slightest variation of temperature in the water from the apparatus will also change it. This heated liquid radiates through the wall of the air chamber and causes the air there confined to expand, which can only find an escape at the bottom, which acts on the liquid in the bottom of the air chamber, causing it to rise and lift the diaphragm and contracting again as the temperature of the water goes down. This first expansion begins just as soon as the temperature of the water in the heater is above the temperature of the outside atmosphere.

GAS AND GAS FITTING.

THE GAS SERVICE PIPE—THE FLICKERING OF GAS CAUSED BY CONDENSATION IN THE PIPES.

ALTHOUGH electricity is doing wonderful things, and particularly in the way of lighting, yet the old reliable gas holds its own for domestic purposes, and is still doing business at the old stand. Illuminating gas, like all other things, is not entirely perfect, but when it is properly and honestly made, carefully delivered to the house, and there properly handled, the results will be so satisfactory that we will have some time yet to wait before we will see anything else that will entirely take its place. Therefore, the average modern house is fitted for the use of illuminating gas, and while experiments and discoveries are going on in electricity for the purpose of bringing it to a more practical shape in regard to its cost and safety, the very same thing is going on in the line of illuminating gas, and fully as great improvements in late years have been made and still greater things are promised. The field of discovery in the line of gas for domestic purposes appears to be as great as that of electricity, consequently our time will not be lost in giving consideration to this subject.

THE GAS SERVICE PIPES.

It is the business of the house owner who intends using gas to lay all pipes throughout, and also continue out and connect with the gas company's main pipe in the street. This is a very important piece of work, and like all other sanitary arrangements of the house it should be carefully and well done.

We often find fault with the gas and the gas company when we are at fault ourselves, in not having our work properly done by skilled mechanics who alone can do this kind of work as it should be done. The gas service pipe must be connected to the main in the street in the strongest manner. The pipe should be the best quality wrought iron, with fittings, if any, of malleable iron. Cast-iron fittings should not be used for this purpose, as they crack easily under heavy weights. The service pipe should be laid with an incline to the main in the street; because the earth being cold which surrounds the pipe causes some of the gas at times to condense and form into a liquid state. With a fall in the pipe to the street the condensation can flow back into the main pipe.

NO FLICKERING OF GAS.

With the service pipe laid in this way there will be no flickering of the gas nor any unsteady pressure, as is often noticed where poor work is done. I have often heard it remarked when the gas began to flicker, or, perhaps went out entirely (on account of the service pipe being trapped so that the condensation could not flow back to the main), that the gas is bad to-night. This is a mistake, and it is our mistake in not having our service pipe properly laid, so that this trouble could never occur. The service pipe must be laid on a solid foundation, so that the weight of the earth which covers it could not press it down and cause it to sag so that water might lodge therein and stop the flow of gas. The gas pipes through the house should also be of best wrought iron and malleable-iron fittings well screwed together with threaded joints. The fittings should be heated and coated with gas fitter's wax in order to fill any slight flaw or sand hole in the casting. All pipes should be laid in a solid way, that is, well fastened, so that they could not move when using a fixture connected with them. After the piping is all done it should be tested and made perfectly tight before allowing the gas to be turned on.

THE GAS FIXTURES.

After selecting your gas fixtures, which, as a rule, give considerable trouble and worriment, you have still another very important duty to perform, and that is to see that the fixtures are properly put together and hung up correctly. This piece of work is very often slighted by allowing some inexperienced man or boy to bungle them up as if they were hanging some oil lamps to a hook on the wall or ceiling. The putting together of gas fixtures and properly hanging them up requires the best mechanical skill, not only because it is very important but because it is hard to do and requires trained experience. After the gas fixtures are all put together and before they are connected to the pipes they should be tested, each one separately, and made perfectly gas tight, and this the experienced mechanic knows how to do, while the other man does not. Then again, after all fixtures are hung up the entire gas arrangements should be tested together, and if any leak is found, made tight.

TO KEEP GAS FIXTURES CLEAN.

This is a matter that should interest the housekeeper, as the question is so often asked,. "how can we clean our gas fixtures?" It depends entirely on how long you have let them go, since they were last cleaned, whether they can ever be cleaned or not. It matters not what finish the gas fixture may have, whether it is gold plate, silver plate, gold bronze, polished brass, or any of the many other finishes, if allowed, the same cause will destroy them all, and that cause is the fly-speck. Most all finishes of gas fixtures are a simple surface finish; they are electro-plated or finished in some other way, and all with a coating of transparent varnish for the purpose of keeping the natural color, and preventing oxidization by the atmosphere, which it does very well. But if fly-specks are allowed to remain on any part of a gas fixture longer than forty-eight hours, there will be spots left that cannot be cleaned by the housekeeper.

USE A DAMP, SOFT CLOTH.

If the fixtures cannot be kept properly covered in fly-time, they can be kept clean by going over them every second day with a soft, damp cloth, and it must not be pressed hard against the fixture, as there will be danger of rubbing off the thin coat of transparent varnish. All we want off are the fly-specks, and if they are allowed to remain for more than two days they will eat in through the varnish and also through the electro plate, and then the more we clean the worse the fixtures will look. Never use powder or polish of any kind for the purpose of cleaning gas fixtures, as it would at once destroy the only protection a gas fixture has, and that is the coat of varnish. After using the damp cloth in cleaning the fixture, dry each part at once with a soft, dry cloth, as it would harm the coating of varnish to allow water to dry on the fixture. Even the perspiration from the hand will sometimes leave a stain that can never be wiped out.

HOW TO PROPERLY RUN THE GAS SERVICE PIPES IN THE STREET UNDER DIFFERENT CIRCUMSTANCES AND CONDITIONS.

To make matters more easy to comprehend, I will add a few special illustrations, showing how such pipes can be laid in a practical and satisfactory manner under different circumstances.

In Fig. 56 is shown a section of a street with the main gas pipe down below the surface and in about the centre, and lateral branches running on each side from the main pipe. As stated before, it is quite necessary to have these lateral branches on the house service pipes rest on a solid bed or foundation. And it often happens that in digging the ditch for the service pipe it is dug too deep, or it may be dug level, and as the pipe must have a pitch back to the main in the street it will have to be blocked up, and it is in this blocking where so much trouble comes from. Never block up a service pipe on filled-in earth or soil. Always start the blocking from the bottom of the ditch or from the lowest excavated part of the ditch. On the right-hand side of Fig. 56 is shown a service pipe laid in the ditch properly graded and blocked. There is no special amount of pitch required for such pipes, only the more pitch they have the less chance they would have to sag down enough to form a water trap; therefore where the ground is soft I would give the service pipe as much pitch as I could, at the same time keeping it enough below the surface to be protected from frost in winter. Under the service pipe, on the right of Fig. 56, is shown some blocking which is quite familiar to the average gas fitter. It consists of some flat pieces; first laying one piece flat on the bottom of the ditch, pressing it down solid, and then standing another piece on top of it in the shape of a prop, notched out on top, so that the pipe will have a sort of saddle-shaped rest on the upright piece. This should be done about every three feet apart for small pipes, such as 1-inch or 1¼-inch; larger size pipes will not require the props so close. After the pipe is all laid, properly graded and blocked as shown, the next thing to do is to test the pipe, for the purpose of making sure there are no leaks, before the pipe is covered up. The pipe being found perfectly gas tight, the ditch can now be filled in. And although the gas fitter has completed the laying of this service pipe, he is not by any means finished with the entire work. It will now be his business to remain on the ground and superintend the work of properly and carefully filling the ditch; for the reason that the average laborer who is engaged to do the digging and filling of such ditches has not sufficient knowledge of the pipes to handle them with the necessary care. Hence the fitter who knows the necessity of being careful must remain there at least until the pipe is covered over. It is not an uncommon thing to find the gas service pipe broken and leaking badly, right after being covered over, by throwing or allowing some heavy stones to fall into the ditch by carelessness or lack of thought on the part of laborers. Therefore it is always better for the fitter to remain on the ground long enough to see that everything is safe, and not run

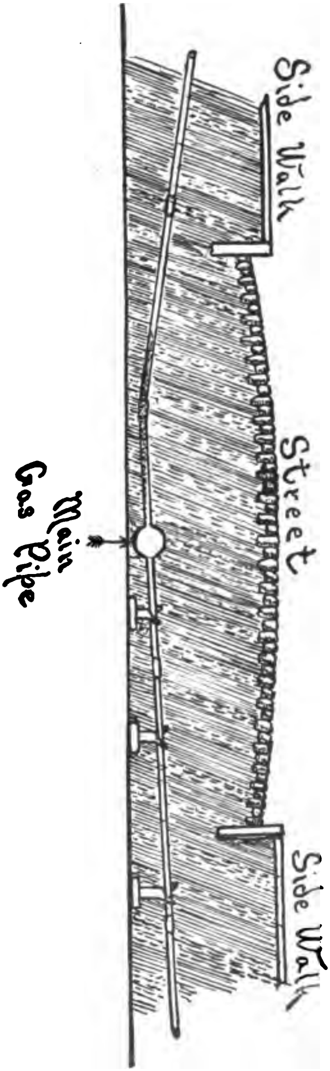


Fig. 56.

the risk of having to go back the second time and do the work over.

Referring to Fig. 56, on the left-hand side is shown another service pipe. This shows the result of not taking the trouble or precaution of properly blocking up the pipe; it sagging down far enough to form a trap in itself, and consequently the flow of gas being stopped every time enough condensation takes place in the pipe to fill the depression. It is from such improperly laid service pipes that the flickering or uneven flow of gas arises. The proper remedy for such a case as this is to have it dug up and properly blocked and pitched. But for temporary relief, it is customary to disconnect the pipe at the meter in the house or building and blow into the service pipe; that will force the water back into the main pipe, leaving the passage free again in the service pipe for a short time. The flow of gas is sometimes stopped by frost even where the service pipe has plenty of pitch; but it is in too cold a place, or, in other words, not properly protected. This occurs generally in the main service pipe where it passes through areaways or under sidewalks, and as a large amount of gas passes through the pipe, a large amount of moisture, in proportion, comes with the gas. Therefore it is the moisture which freezes and clings to the sides of the pipe, something like heavy frost on a window, but coarser, and looks very much like coarse tablesalt. It keeps on accumulating—gradually closing in toward the centre from all sides—until the passage is entirely closed.

Fig. 57 represents the appearance of a gas pipe nearly closed by such frost. To properly remedy this trouble the pipe should be covered with some hair felt or woolen material; dry sawdust is sometimes used and placed in a box around the pipe. For temporary relief, by striking the pipe a sharp blow with the hammer the frost will fall from the sides of the pipe and lie at the bottom of the pipe, as shown in Fig. 58. This does not clear the pipe entirely, but will allow gas to flow through the upper part. Now this frost cannot be blown back into the main like water, and to clear the frost out entirely we pour into the pipe at the meter connection a half pint or so of alcohol, which melts the frost and car-

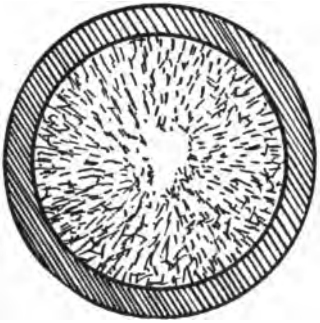


Fig. 57.

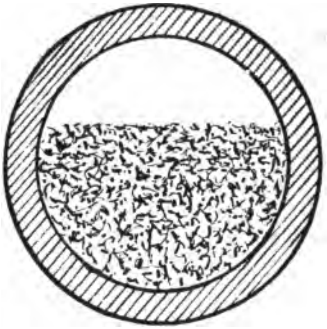


Fig. 58.

ries it along to the main, leaving the pipe clean and free again, as shown in Fig. 59.

THE GAS SERVICE PIPE PITCHED DOWN TO THE HOUSE.

It often happens that in places where the main gas pipe is located in the opposite side of the street, the distance will be too far to carry the service pipe with an elevation up to the house, and at the same time have enough covering on its highest points to properly protect it from frost. In such cases it becomes necessary, or it is sometimes better, to pitch the pipe down from the main to the house, as shown in Fig. 60. Under these circumstances we will have to make provision for the condensation or water, and we do so by placing a small drip-can, as shown at *D*, Fig. 60, placing

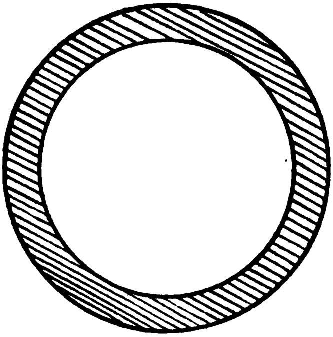


Fig. 59.

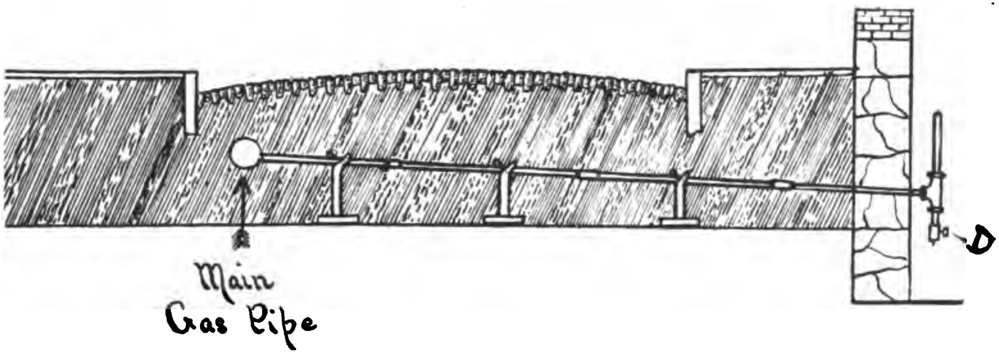


Fig. 60.

a tee on the service pipe on the inside of the cellar wall, looking up and down, so that any water that may come through the service pipe from the street, or from the vertical line to the meter, will fall into the drip and there remain until drawn off through a small pet-cock, which is placed at the bottom of the drip for that purpose. In places where there is depth enough, a short piece of pipe will answer for the drip in place of a special arrangement made for that purpose.

OBSTRUCTIONS IN THE WAY OF THE SERVICE PIPE, AND HOW TO GET OVER THEM.

The fitter will find places where he cannot run the gas service pipe on the line he would like to on account of obstructions of various kinds, such as large main water pipes, sewers, etc., and he will have to use some judgment in getting over them. The best and easiest way is shown in Fig. 61, two ways of making a proper job where such obstructions exist. We will suppose the main gas pipe to be in the middle of the street, as shown, and to carry the service pipe on a proper grade to the house we would come in the very centre of a main water pipe, marked *A* on the right-hand side of Fig. 61; and to rise above the water pipe, and there take our pitch to the house, would bring our service pipe too high. Therefore, to carry the exact grade that we would wish to where no obstruction existed can be accomplished by connecting the pipe in a loop around the wa-

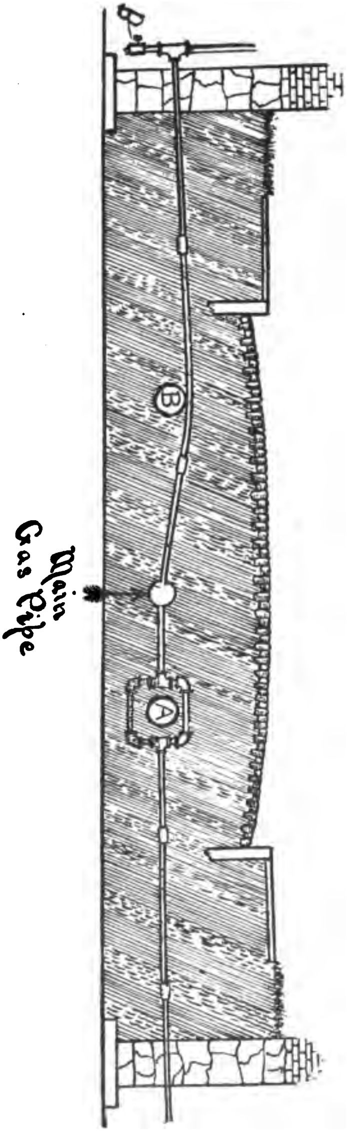


Fig. 61.

ter main, as shown. The bottom part of the loop will, of course, fill with water to a level of the bottom of the outlet on the tee nearest the main gas pipe, as shown by the dotted lines, while the gas will pass around the upper part of the loop unobstructed. In such cases the water pipe makes a good support or rest for the loop, while there may be room enough or clearance at the bottom to connect up the loop. On the left-hand side in Fig. 61 we consider *B* an obstruction, and we get over it by pitching the service pipe in two ways: first, rising from the gas main to the top of the obstruction, and then carrying the pipe on an incline down to the house, placing a drip at the bottom, marked *B*, as explained in Fig. 60. In this case part of the condensation falls back into the street main, while another part of it falls into the drip located in the cellar on the pipe.

HOW TO PREVENT GAS COMING INTO THE HOUSE FROM THE STREET THROUGH THE EARTH.

A most dangerous thing connected with gas is where it finds its way into the cellar of a house from the street through the earth; and this is no uncommon occurrence in any place where gas is used. The danger from this takes place principally in winter, when the ground is all covered over with ice, and the earth frozen solid for some distance down. The escaping of gas in the ground comes generally from some of the gas mains, and they are caused to leak by the settling of the earth under them, or sometimes from the heaving of the ground by frost, which also moves the pipes and loosens the joints, causing them to leak. I have often seen places where the gas main leaked so badly that the gas killed all the trees and even the grass on each side of the street for several blocks, and also where people had to move out of their houses on account of gas coming in from the street in the same manner. Often explosions take place in cellars by this gas being accidentally ignited. Where gas escapes from a pipe it has a pressure which forces it through the porous soil and soon finds its way to the surface, where it will be quite noticeable to the smell, and is often strong enough to light; but in winter the gas cannot find an escapement to the surface of the earth so easy, and naturally takes the next easiest way of escape, which is often found to be along the service pipe channel where the earth has not been tightly filled around the pipe, and in this way the gas flows into the cellar of the house. To guard against such a trouble we will have to make a more easy way for the gas to escape than by going all the way along the service pipe to the house, and this may be done by putting in ventilators along the line of service pipe, as shown in Fig. 62.

This works on exactly the same principle as the plan for preventing rats from gnawing holes through floors and partitions, and that is, to make the rat-hole large enough for the rat to pass in and out with ease, and he will not waste his time in biting wood. In Fig. 62 is shown again the main gas pipe in the centre of the street, with service pipes branching off from both sides, and on the right-hand side, just inside of the curbstone, is placed a hitching-post of iron, hollow on the inside, which extends down to and straddles the service pipe. Above the sidewalk are holes in the hitching-post, which makes it a ventilator, and around the bottom of this post where it straddles the gas pipe we fill in with clean gravel, and for some distance along the pipe toward the street—this is shown by the coarseness of the soil in the cut—and on the other side nearest the house we cover the gas service pipe with fine sand and soil for some distance toward the house, as shown by the fine shading in the cut. It will be seen that any gas coming along the sides of the service pipe from the street will have a much easier way of escaping through the ventilator than passing on through the fine soil or sand and reaching the cellar of the house; and on the left-hand side in Fig. 62 is shown a piece of pipe with a cap on, a few inches above the surface, for ventilation, with the bottom fixed the same as the one on the right side. This is a safe thing to do, and as its extra cost is very little, there is no excuse for it not being done in all cases.

WHERE TO LOCATE THE RISER.

After having completed the laying of the gas service pipe from the street to the house, the next thing to do will be to locate the riser. If it is possible to do so, the

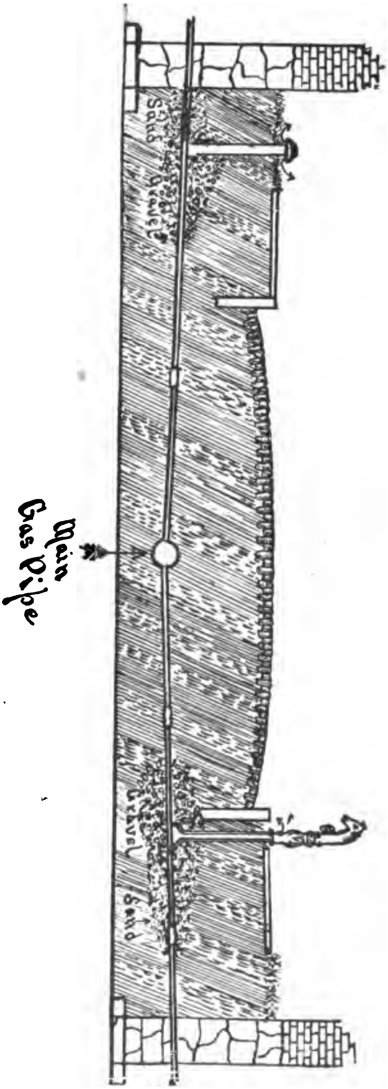


Fig. 62.

best place for this pipe is in some inside partition, never on an outside wall unless it is well wrapped or protected from cold drafts. The riser, like the main service pipe, will fill with frost, although it may stand in a vertical position, if it is located in a cold place, and for this reason I would locate the riser in some inside partition, a few feet in from the front of the building. The gas service pipe, as a rule, is introduced into the building through the front side, and therefore the riser should start from that point, connecting with the several branches or outlets as it extends, and diminishing in size according to the number of outlets to be supplied.

SIZES OF GAS PIPES FOR GOOD WORK.

A gas service pipe laid in the street should never be less than one-inch pipe, no matter if it only had to supply one burner. The risers should also be of good size. The meter connections or pieces of pipe that are used to connect with the couplings of the meter should always be one size larger than the size of the couplings.

In late days the use of ¼-inch pipe for anything in gas fitting is scarcely used at all, and I would not recommend its use, although enough gas will pass through a ¼-inch pipe to supply several burners, yet its chances for being partly clogged by dirt and one thing and another are so great that it is not advisable to use it.

THE SIZE OF DROPS.

The fitter must remember that the regular size connection on all ordinary sized gas fixtures, whether for 1 gas jet or 6, is for ⅜-inch gas pipe; therefore all drops, unless specified, will be ⅜-inch pipe. Drops mean the pieces of pipe which extend down through the ceilings, and to which the gas fixtures are connected. In most places the different gas companies have rules which call for certain sizes of pipes for a certain number of burners or outlets; and as these rules are not uniform throughout the country, the fitter will have to be guided in regard to the sizes of pipes by the list furnished by the local gas company in his own locality, or wherever the work is to be done.

IT PAYS TO HEAT AND WAX GAS FITTINGS IN ALL CASES.

Gas fittings, as a rule, are found to have more sand holes in them than any other kind of fittings, perhaps because they are quite thin, and, therefore, it is always the best, quickest, and safest way to heat and wax every fitting before they are placed in position; by doing this there will be no time lost in looking up leaks in testing the gas pipe. It rarely happens that leaks are found in the pipe, but most generally in the fittings, and when found in the fittings come, as a rule, from either sand holes or cracks in the fittings. Gas fittings are malleable iron, so as to be strong or tough and not easily break or crack. Cast-iron fittings are not the proper things to use for gas fitting, and should not be used, besides they are very clumsy, and look bad where they are exposed.

BUSHINGS SHOULD NOT BE USED.

There is no excuse for using bushings on gas-fitting work. Gas fittings are made in all the reduced sizes. The use of bushings in gas work is not only a poor piece of work, but it looks poorly and should not be allowed, at least on new work, and only on old work where it is absolutely necessary.

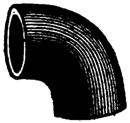
NAMES AND SHAPES OF THE DIFFERENT MALLEABLE-IRON GAS FITTINGS AS THEY ARE CALLED AND KNOWN BY THE PRACTICAL GAS FITTER.

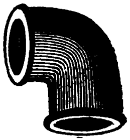
Having gone over the matter of the sizes of pipes for the different numbers of burners, and understanding that there are all kinds of reduced fittings and shapes for special places, we will proceed to do the complete gas-piping of an ordinary dwelling-house, and whether we get out our pipe in the building which is to be piped or cut it out at the shop, it will pay us to make a complete plan of the work to be done. There is too much time lost in taking the measure of one piece at a time and then cutting it out, and also too much climbing; so it would be better to take the measure of all the pipes at one time, or at least one floor at a time.

HOW TO TAKE MEASURES FOR GAS PIPES IN A HOUSE.

As a rule, the gas fitter never takes the measurements for his pipes from the architect's plans, but simply

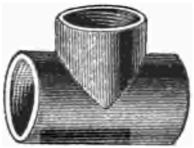
ELBOWS.



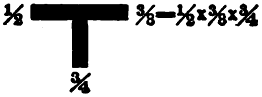


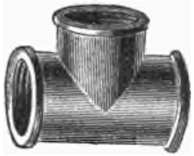
TEES.

In describing **Tees, the run is first named**, then the outlet, **thus.**



PLAIN

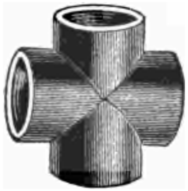




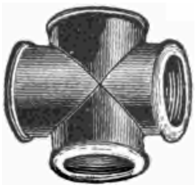
BEADED.

CROSSES.

The outlets of a cross are always the same size, and both denoted by the last figure.

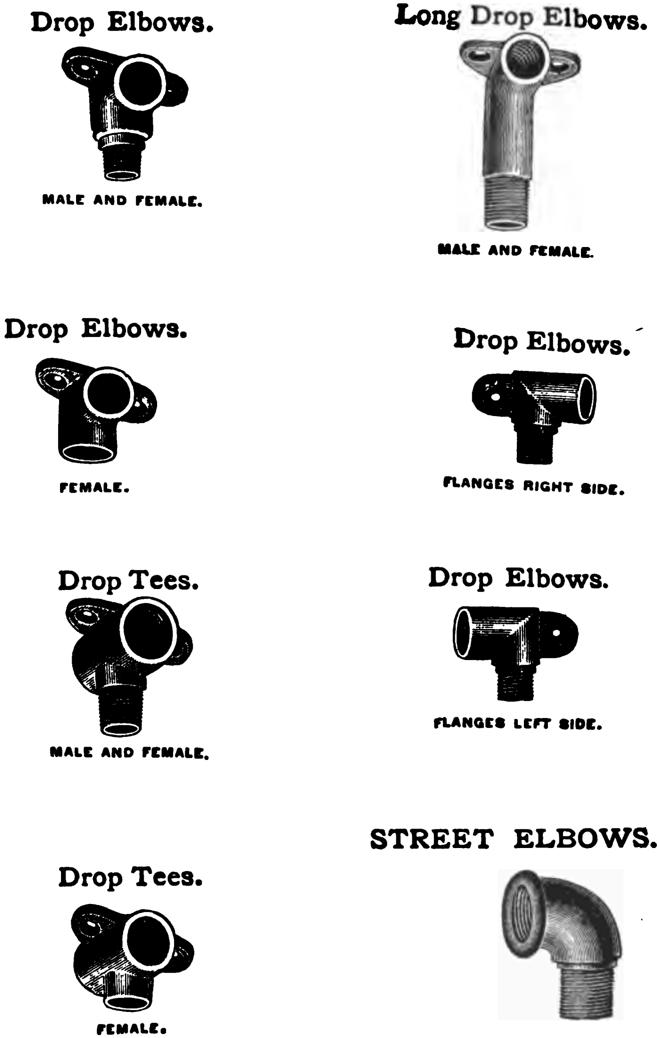


PLAIN.



BEADED.

Fig. 63.



Drop Elbows.

MALE AND FEMALE.

Drop Elbows.

FEMALE.

Drop Tees.

MALE AND FEMALE.

Drop Tees.

FEMALE.

Long Drop Elbows.

MALE AND FEMALE.

Drop Elbows.

FLANGES RIGHT SIDE.

Drop Elbows.

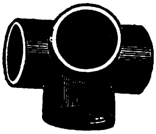
FLANGES LEFT SIDE.

STREET ELBOWS.

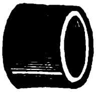
Fig. 64.

ELBOWS.

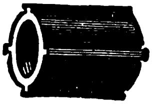
WITH SIDE OUTLET.



FOUR-WAY TEES.



CAPS.



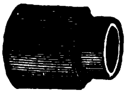
COUPLINGS.

RIGHT AND LEFT.

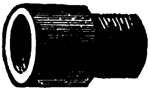
PLUGS.

COUPLINGS.

RIGHT HAND.

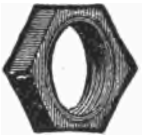


REDUCING COUPLINGS.



EXTENSION PIECES.

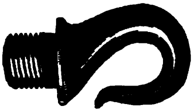
MALE AND FEMALE.



LOCK-NUTS.

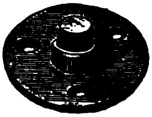
Fig. 65

locates the different outlets where called for by the architect, and, consequently, such measurements are never taken until the building to be piped is enclosed, having the joists in place and the roof on, and before any floors are laid. Much climbing and crawling around a building where the floors are not laid and where no regular stairs have been put in place is very hard work, and besides it is quite dangerous, so that the less we have of such work the less risks we will have and the quicker the work will be done. My plan would be to take the measurement of every piece of pipe to be put in the building at one time, have them all cut out, screw on all the fittings, then, with a good gasoline furnace or any other good heating arrangement, I would heat all the fittings and carefully wax them with a good quality of gas fitter's wax. I might state that in screwing on the fittings to each piece of pipe I would use a little white lead, and only place it on the thread of the pipe, so that in screwing the fitting on to the pipe the surplus of white lead on the thread would be pushed to the outside in place of lodging on the inside of the fitting and partly clogging its opening. After the fittings had cooled and the wax became hard on them, I would carefully tie up the pipe in convenient bundles so that they could not only be handled with ease, but that where there were several pieces of one kind they might be tied by themselves, such as drops for the first floor, which would be about 14 inches, while drops for the second

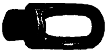


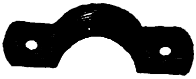
CHANDELIER HOOKS.

Wall Plates.



Chandelier Loops.





STRAPS.
TINNED.

Fig. 66.

floor would only be about 10 or 11 inches long. They should be bundled separately and marked for the floors they are intended for, so that when taken to the building each bundle could be placed in a close position to where it was to be used, which would save a great amount of time. The same thing should be done with the pieces for side lights; tie them in a separate bundle also. This same principle could be still more carefully carried out to good advantage in regard to the saving of time, and that would be to divide the plan up into what might be called right and left sides, calling all the pieces on the right-hand side of the main floor line right, and all the pieces on the left-hand side of the main pipe left, and designating them by either the letter R or the letter L—R for right side and L for left side. In this way all the pipes having the same letter could be placed together as they are made ready and carried to the building in the same way as drops, so that in opening them out they could be placed on the side of the building to which they belonged, and when wanted to be screwed up in their places there would not be much trouble to find each piece as it was wanted.

A COMPLETE PLAN OF THE PIPES FOR A HOUSE.

In the next three drawings, Figs. 67, 68, and 69, are shown a complete plan of the gas pipes for a house. This general principle of doing gas fitting has been practically carried out for many years by the author, and

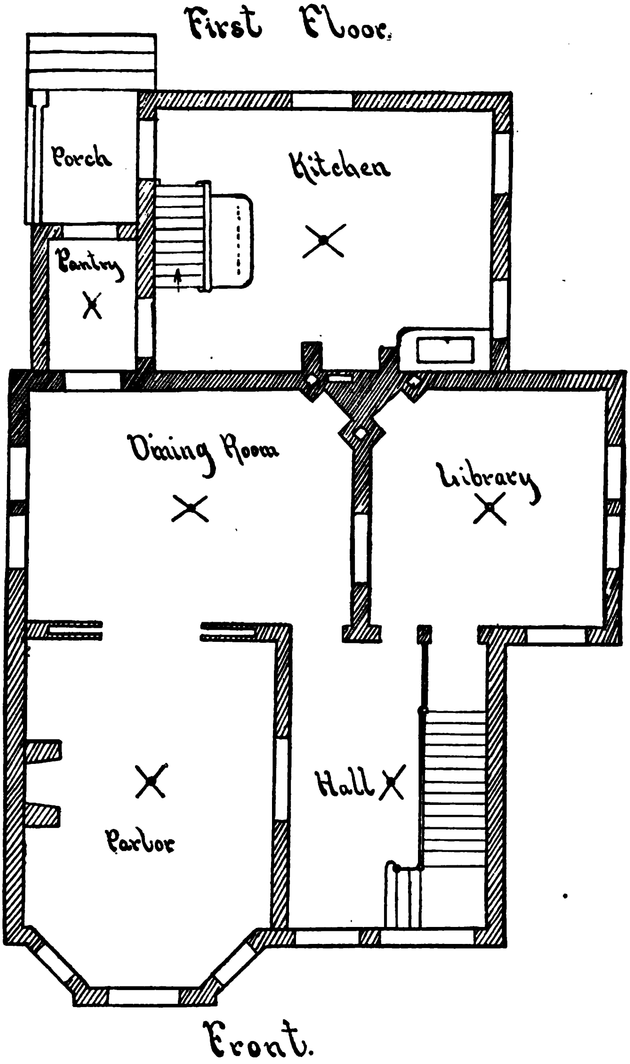

First Floor.
Porch
Kitchen
Pantry
Dining Room
Library
Hall
Parlor
Front.

Fig. 67.

it is still being carried out with great satisfaction by fitters of experience and ability. Fig. 67 represents the first floor of the house to be piped for gas, and Fig. 68 shows the second floor of the same house. It will not be necessary for the fitter to make regular floor plans of the house, as shown in Figs. 67 and 68, in order to take the correct measurement of all the pieces of pipe to be put in, but simply a plan of measurements, as shown in Fig. 69.

By referring to Fig. 67 it will be noticed that all the lights to be furnished are drop or ceiling lights, as marked by a cross in the centre of the different rooms, the hall, parlor, dining-room, library, kitchen, and pantry, or six in all, and it will be noticed by referring to the second floor plan, Fig. 68, that we have only three ceiling or drop lights, but we have here also a number of side lights, and these are marked by a round dot where they are to be located in the side walls or partitions of the room. It will also be noticed that there are 10 side lights on the second floor as well as the 3 ceiling lights, and are several more than are wanted on the first floor of the house. This is not done because more light is required on the second floor than on the first floor, but for the purpose of having the gas brackets or jets in a more convenient place, such as each side of a dressing-case; and oftentimes we have toilet lights placed over the top of the dressing-case in the centre, so that the pipe fitting for the second floor of a house is always

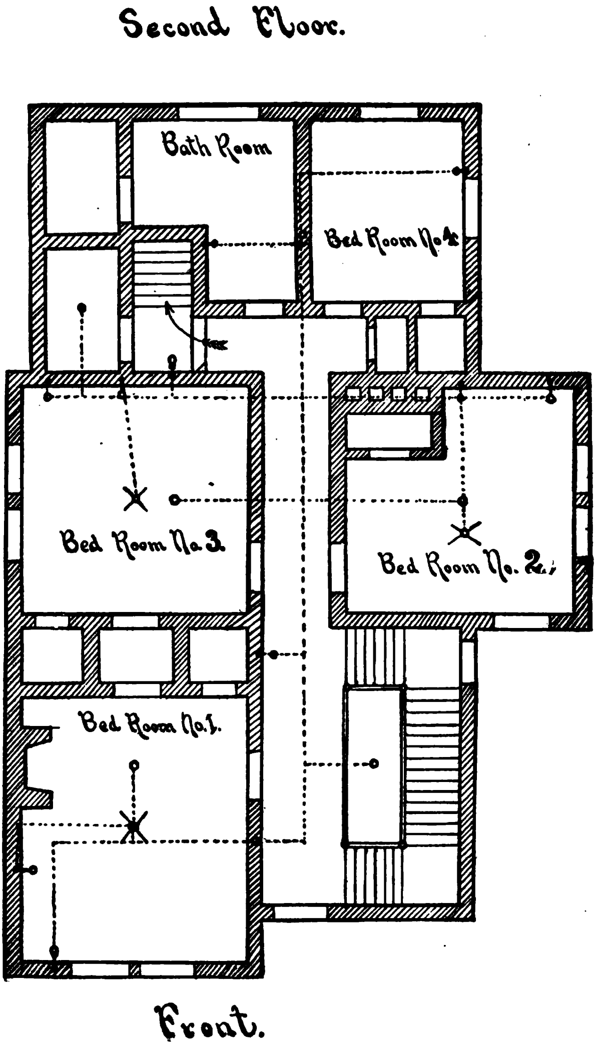

Second Floor.
Bath Room
Bed Room No 4
Bed Room No. 3.
Bed Room No. 2.
Bed Room No. 1.
Front.

Fig. 68.

about double that of the first floor. In Fig. 68, the second floor plan, is shown some dotted lines. These lines show the exact position of the pipes when in place, and from this we take our measurements. As a rule, the main line is placed in about the centre of the house, as shown, and about the centre of the passage or hallway, with the branches taken off for both sides and for both first and second floors.

THE STARTING POINT.

To properly carry out our plan for correct measurements we must have some given point to start from, and then go on with our measurements. This given point we must remember when we come back to the building with the pipe to be placed, and commence the work of laying the pipe from the exact point where the first measurement was taken. And to do this we will take a little sketch of the front of the building, just enough to get our starting point from, as shown in Fig. 69. It will not be necessary to make any further sketch of the building. Having decided to locate our riser in a central partition and about 6 feet in from the front of the house, we mark our measurement plan to that effect, as shown, so that it would not make much difference whether the man who took the measurements for the pipes or some other fitter came back to put the pipes in place; and in this way, even if the man died after cutting out all the pipes for the job, there would be no trouble about any other person being able to tell where each piece of pipe belonged. Having the starting point settled, we should strike a chalk line down the centre, as shown, for the main line, having it perfectly parallel with the sides of the building, so that any lateral branches taken off the main pipe could be carried at perfect right angles. It will now be necessary to get the exact centres of our different rooms for the drop or ceiling lights, and although the floors may not be laid when we are doing this part of the work, we will have to keep the centre points in some way, so that they can be found when the fitter comes back to place the pipe, and not have to measure it over again. A good way to do this is to mark on the side of the joist nearest to the centre of such a point where it comes between two joists, with chalk or lead pencil, so that it may not be blotted out: First, one long mark from top to bottom of the joist, and then along the side the distance from the joist, something like this: 5 inches out, or whatever the distance may be. This means 5 inches from the side of the joist, which is marked in a right angle, to the centre of the drop. It is not necessary to make the plan which the measurements are put on to any particular scale; simply make it large enough so that there will be plenty of room to mark the different lines on it without crowding them too close together.

THE PLAN MUST BE MADE FIRST.

First make the plan as shown in Fig. 69, numbering each piece, beginning at the head of the riser, and call the largest piece starting from the riser No. 1. The riser may or may not be put in at first and called No. 1, as that can be put in afterward if desired. Then number each piece on the whole plan except the drops, which, as stated, are all the same length on the same floor, and may be counted separately. Then if it is desired to make a distinction between the right or left side of the main line, for the purpose of more readily locating each piece when they are to be screwed in, we will use the letters R and L. These letters will be used only on pieces of pipe placed on either side of the main centre line, and all the pieces in the main line will have only their numbers marked, so that they may be bundled together and kept separate from the other pieces. Starting at No. 1, as shown in Fig. 69, in the main line, it is marked No. 1, 1-in. P, on one side of the line, which means its position in the line of pipe and also its size, while on the opposite side is given its length, which is 6 feet. The next piece is No. 2, and is marked in the same way. It will not be necessary to use the letter P for pipe, as shown. The third piece happens to be a branch from the main line to the right side, and it is called 3, R, ⅜-in. P. This means that it is called No. 3, and that its size is ⅜-in. pipe, with its length above, which is 4 feet. Then comes the first drop, which is the drop to light the front hall, and it is marked, D to hall. D in this plan means that the pipe extends or drops down from the fitting it screws into, so that should we run down from some point to place a side light, as we often have places where it is much nearer and more convenient to carry a pipe down for such purposes than to carry it up—in such cases we also use the letter D, which, although it is too long for a drop, the fitter will know by the letter D marked on it that it must be for some side light which is carried from some point above. In the same way we use the letter U, which means that the pipe, in place of being laid flat, is to extend in an upward position. We may also use the letter S on the plan, to let us know that the piece of pipe having S marked on it is intended for a side light, because side lights are sometimes taken from risers; and in such cases the fitting for such a place would not be a bracket or drop ell. Again, where we have ceiling lights for the second floor rooms, we carry risers up for such drops from the nearest points, and such pipes are marked, as shown in Fig. 69, by the dotted lines. In cutting the joist for the main or any other gas pipe it should be deep enough, so that when the floor is laid it will be a little below the bottom of the floor, so that the floor will not press against the pipe. The pipes should be carefully stayed with wrought-iron hooks, and especially in the case of drops and side lights they should be made perfectly solid, so that the weight of gas fixtures could not move them in the least.

TESTING THE PIPES.

After all the pipes are laid the openings should be capped up and a pressure of air put into the pipes, with a gauge placed to show whether they are perfectly tight or not. This should all be done before the floors are laid. A pressure of about two pounds will be sufficient to test gas pipes. If they stand perfectly tight at that

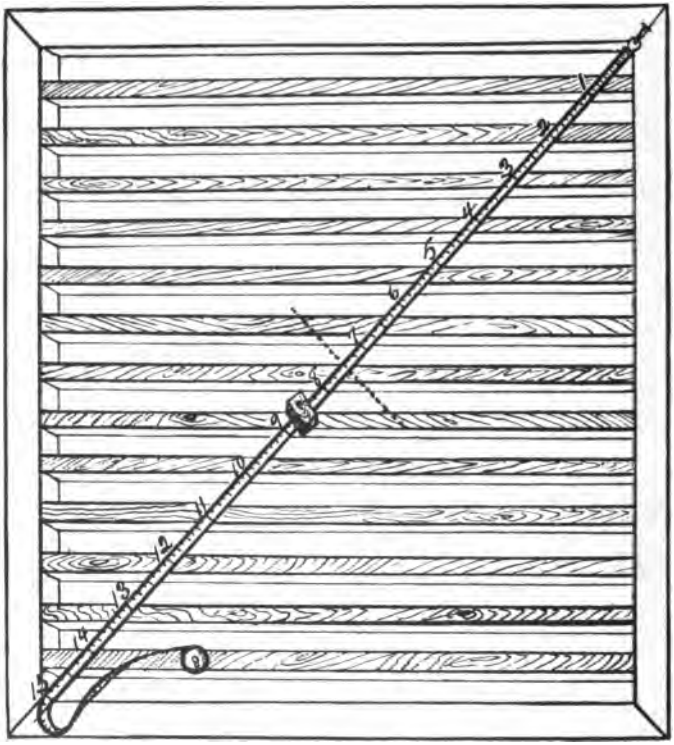


Fig. 70.

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pressure for 24 hours they will be safe for the use of gas.

In Fig. 70 is shown a quick and simple way of getting the centre of a room by a single measurement. In this Fig. is shown a tape-line stretched across the room from one corner to the other. This measurement may be taken by one person by simply hitching the end of the tape-line, as shown, to a nail placed at one corner, while the fitter who is taking the measurement holds the other end. The line is held close to the top of the joists, and whatever the distance may be from one corner to the other, as shown by the tape-line, one-half of this distance will be the centre of the room. To keep the tape-line in its place until the fitter comes back from the corner of the room where he held the line is placed a weight to hold it, as shown. It will be seen that one-half the distance from corner to corner, and directly under the tape-line at that point, will be the exact centre, therefore it is not at all necessary to take any further measurements. Most any shaped room can be measured for the centre in the same way. If the fitter has a helper to assist him in taking such measurements, the helper can hold one end of the tape, and in this way the measurements can be taken in much less time, which will more than pay for the expense of the helper.

RUN ALL GAS PIPES ON AN INCLINE IN COLD PLACES.

The fitter must remember that although the gas pipes may be placed on the inside of a building, they are still liable to be affected by condensation where they are located in cold places. Therefore it will be necessary in such places to have the main pipes pitch back to the riser; and where that cannot be done pitch them in any direction, placing a drip at the lowest point, where the condensation may find its way and be taken care of.

FOR THE PROTECTION OF THE GAS FITTER.

That the gas fitter may protect himself against having to repair broken gas pipes on a new job, caused by some other mechanic or person after the fitter has completed his work, he should make it a point to complete his pipe work properly, test it, and then call in the architect or owner, or whoever may have the work in charge, and show to such person or persons that the work is complete, also tested, and is found tight. Then at that minute have a certificate signed to that effect. This will save a large amount of trouble that may arise later on. It will also make mechanics working at some other branches in the same building be more careful about how they use gas pipes that are already finished and in their places. It is quite a common occurrence to find a number of gas leaks in the pipes of a new house just as soon as the gas is turned on, and it is simply because some other mechanic or person in placing some of their work moved or bent the pipes, because the pipes came a little in the way of something they had to place, and the pipes are often broken by careless persons allowing pieces of heavy timber or even their tools to fall on the pipes, and nothing is said about it until the owner comes to live in the house, and finds that the gas escapes from under the floor or from the inside of the plastered walls. Now this should not be laid to the fitter who did his work correctly, and where he does not protect himself against such matters he will be put (in nine cases out of every ten) to more expense than the profits he made or the jobs amounted to. This same precaution for the protection of the fitter is also the very best thing for the architect or owner, as they will be more sure of a good and safe piece of work, and the expense caused from any carelessness placed on the proper persons who were the cause of such. A little advice to the householder as well as the fitter in regard to how gas leaks may be temporarily stopped in cases of emergency may not be amiss.

THE MOST DANGEROUS THING.

One of the most dangerous things that could happen in our house, and yet one most easily fixed temporarily by any member of the family, is a break or leak in the gas pipes or fixures. If a strong oder of gas is suddenly noticed in the house we may be sure that a break has occurred in the gas pipe, or some burner key left open in some of the fixtures. The first thing to do in this case is to shut off the gas from the entire house; and that can be done near the meter, where there generally is, or always should be, a stop-cock for that purpose. Now, if the gas smells strongly in the cellar, and a light is required to see where to turn it off, we must be careful with the light, for fear of igniting the gas, which would result in an explosion. Before entering the cellar with the light, first open the cellar windows and outside doors, if any, so that fresh air can circulate through the entire place, which would have a tendency of carrying some of the gas out or weaken it so that it could not ignite by coming in contact with a flame. This being done, we can safely enter with our light, and after the gas is turned off the fixtures throughout the house should be examined to see that none of the keys have been left open.

WHAT TO DO IF WE FIND THE LEAK.

If the trouble is not in the keys of the fixtures and appears to come from the cellar, we should never attempt to discover the leak by applying a flame to the pipes. This can be done with safety at times in certain places when the leak is a small one, but it is a very dangerous thing to do where there is a strong odor of gas or where the pipe is situated between the floor and the ceiling. This place may become filled with gas from a very small leak and be strong enough to ignite if touched by a flame of any kind. If the break in the pipe is not large enough to see the gas should be partly turned on again, and wherever it appears to be strongest, there the pipes, if exposed, should be covered over carefully with soapsuds, using a small soft paint brush to apply it, and while doing so carefully watch for soap-bubbles, which will be blown up by the escaping gas should any of the suds fall on the break. And should we discover the leak in the gas pipe, it can be stopped temporarily by applying a little common laundry soap, which will do very well and be entirely safe until we get time to have it permanently fixed.

I claim that the man in any branch of mechanics should be thoroughly acquainted with the different mechanical arrangements he handles; that is, he should know the principles upon which they work, and not merely know how to connect a pipe to them. It does not require much knowledge for that, therefore the gas fitter should know the entire principles of the gas meter.

LIGHT ON THE METER—THE MYSTERIOUS GAS METER FULLY EXPLAINED—IT CANNOT CHEAT THE CONSUMER.

The gas meter has been the cause of many curious comments and reflections from time to time on the gas companies; but, like all other things not fully understood, we appear to have a suspicion about them, and this might well be said in regard to the most faithful and wonderful piece of mechanism known as the household gas meter. It may be surprising to some to know that the meter cannot cheat the consumer; that it cannot register more gas than passes through it. But, on the other hand, it is quite possible for more gas to pass through than will be registered. There are several kinds of mechanical arrangements or machines intended to measure gas for illuminating purposes, yet only two of these arrangements have ever come into general use. One principle used is called a wet meter, because water or some other liquid is used in it. It consists of a drum which is caused to revolve on its axis by the ingress and egress of the gas. By these revolutions communicated to a set of cog-wheels the amount of gas used is indicated on the face of the meter.

THE DRY METER.

The other meter used is called the dry meter, and it is used more generally for domestic purposes, as it has the advantage of not freezing in winter, and the gas in passing through it takes up no additional moisture to be condensed in the pipes. This is truly a wonderful piece of mechanism, and works with life-like action. Its operation is something similar to that of the human heart and lungs. If we give this matter just a little consideration we will see how perfect the meter must be in order to do its work satisfactorily. It must measure the cubic feet of gas as it passes along into the house, and to do it without in the least way affecting the pressure or flow of gas. This meter has four separate compartments which are filled and emptied each one in its turn. The amount of gas used is figured from the size of these compartments and the number of times they have been filled and discharged. Therefore the meter cannot record anything unless each compartment is entirely filled at every operation.

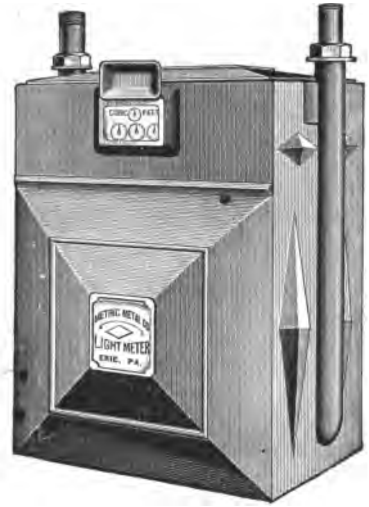


Fig. 71.

In this gas meter we have two canvas or sheepskin bags; one on each side of the meter, with a partition between them. The bags are made quite flexible and yet strong enough to hold the pressure of gas. The mouth of each bag, and also of the compartments in which the bags are placed, are connected to port-holes in a set of slide valves which are located in an upper section of the meter above the measuring compartments. These slide valves are very nearly the same as the main working valves in the steam chest of a locomotive or any kind of double cylinder steam engine. By the inflating and collapsing of the bags, with a combination of levers attached to them, a rotary motion is produced, which is then communicated to the clock-work and indicated on the dials. The levers which transmit the motion from the flexible chambers are the same as the piston and connecting rod attached to the crank of the driving wheel on a steam engine in order to complete the revolution.

IT GIVES FULL MEASURE.

There is only one difference between the action of this gas meter and the double-acting steam engine; that is, in the meter there is no fly-wheel or other moving part that will give momentum to the machine and make it turn round without the flow of gas passing through it. Therefore it cannot register unless the gas is used. Each compartment must be entirely filled during its action, or the rotary motion which is necessary to record the amount used cannot be accomplished. Neither can it run backward, because it is provided with a small rachet which rises and falls over the arms of the revolving levers, and should it through any cause move backward it would be held fast by the teeth of the rachet; and so the dial-hands could not be moved back so as to indicate less than the amount of gas that had passed through the meter.

CAN PASS WITHOUT INDICATING.

It is possible for more gas to pass through the meter than will be registered. In this case of course the gas company is the loser. It is much more to the interest of the gas company to see that the meter is perfect than it is to the consumer, because if the valves leak (and I never knew one that would remain perfectly tight very long) the gas would pass through the seat and escape to the outlet without going into any of the measuring compartments or moving the machinery, just the same as steam escapes from the steam chest with a leaky valve and passes directly to the exhaust pipe.

THE BILL NOT ALWAYS THE SAME.

There are also many misunderstandings and considerable trouble through the monthly gas bill not being the same each month, although the same amount of gas is thought to have been used. The same amount of gas may have been used each month, and still the bill be different without any fault or mistake of the gas company. It is on account of the way the meter is read, or the position of the hands, and if we pay for more than we use one month, we will pay for less than is used the following month. So it straightens itself out in the course of a little time, and sometimes the statement taken is correct. The housekeeper should understand how to take the statement of the meter herself and should do so, keeping a record of it in a book for that purpose, so that notes could be compared with the gas company's agent when the statement is taken by him. In this way there would be no misunderstanding in regard to the amount of gas used, and less bad feelings between the company and consumer.

HOW TO CONNECT A METER.

The distributing pipes in a building, together with the supply line pipes, should be tested before the meter is connected, to avoid the possibility of damaging the meter by an excessive and sudden pressure; the line pipes should also be blown out so that the possibility of dirt being carried into the meter by the flow of gas will be obviated.

After connecting the meter, great care should be taken to turn the gas on gently until the pressure has had a chance to equalize on the distributing side; this also prevents a sudden strain on the meter, which might result where the pressure is over 4 ounces. A meter should not be set in a place warmer than 100 degrees or colder than 40 degrees, as the oil in the diaphragms is susceptible to heat and cold.

One complete revolution of a hand registers the number of cubic feet marked above the dial.

Put down the figures that the hand has just passed on each dial, add two ciphers, and the number obtained will be the amount of gas in cubic feet that the meter has measured. From this amount subtract the last reading of the meter rendered, and you have the amount of gas consumed in the intervening period. Example of reading a meter from the above dial, 53200.

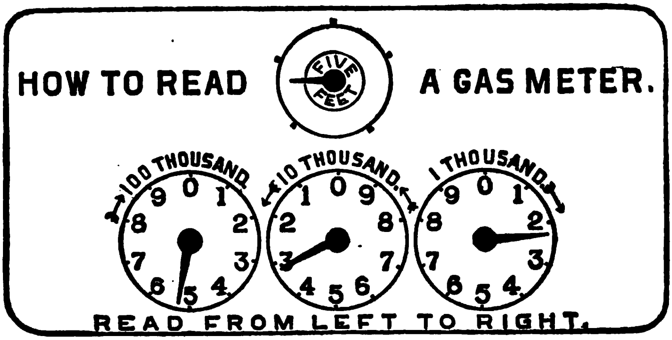
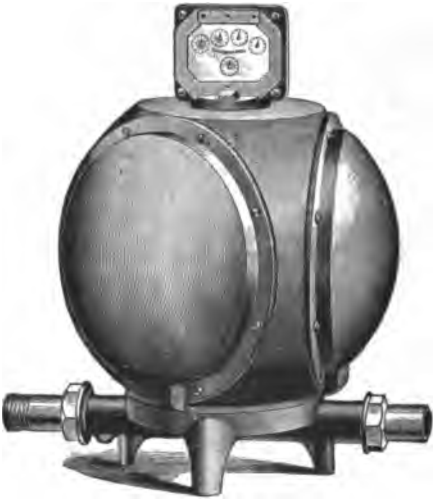


Fig. 72.

It will be noticed in referring to the gas meter, Fig. 71, that its shape is square, and it is also made of sheet tin or tin plate; therefore such a form and such light material would not stand much pressure. And to measure gas where the pressure is too high for such a meter as described, such as will be found in the natural gas fields, I show "The Tobey Meter," Fig. 73, a very ingenious apparatus for measuring natural gas, or any gas having a high pressure. It is manufactured by the Metric Metal Company of East Tenth Street, Erie, Pa.; as will be noticed, it is cylindrical in shape in its body or centre, with three convex plates on its sides. These convex surfaces give room on the inside for the diaphragms or bellows to work, and at the same time make a solid background for the diaphragms to rest against, so that any excess of pressure will not injure them.



Fig, 73.

Figs. 74 and 75 are sectional cuts of the same meter, which show its interior arrangement. The valve in this meter differs from the valve described in the square meter; this, although a slide valve, does not move in a straight line backward and forward, but moves in a sort of a circular shape and is not held at a central point.

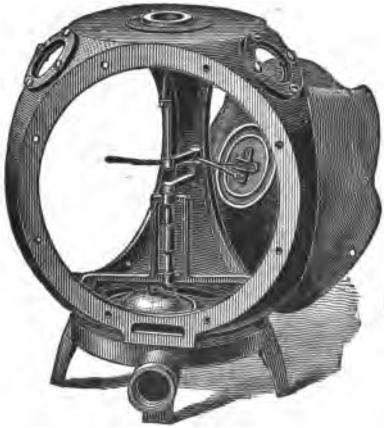


Fig. 74.

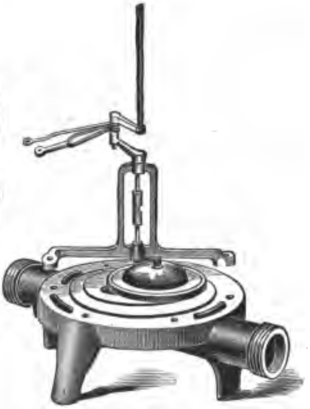


Fig. 75.

Through this meter a perfect and steady flow of gas is had, and without the slightest noise; its metal parts are composed of iron and brass.

PRACTICAL ADVICE TO THE GAS FITTER.

It is one of the peculiarities of nature for material things to decay or wear out; and the thing or material having the most work to perform will naturally wear out the soonest. Therefore the gas keys of fixtures that are continually being turned on and off have considerable work to perform, and sooner or later will require some attention in regard to repairs.

Now the gas fitter is very often called upon to simply tighten up a gas key, or stop some little leak, as the people think, in the gas fixture or fixtures in the house. Oftentimes the fitter gets orders to put on new tips and go over all the gas fixtures in the house and see that they are in good order. In such a case, as will be noticed, the entire house and all the valuable things in it are trusted with the fitter and perhaps his helper, who are sent to do the work. This is a very important matter for the fitter who has an employee whom he must send to do such work, or even if he must do it himself, not only on account of the work to be done, but how he and his helper, if he has one, should act and carry themselves through that house. This is now a finished house, not a building in the course of erection and occupied by other mechanics like himself, but furnished perhaps in most elegant and tasty style, and occupied by persons of taste and refinement. Therefore the fitter who goes to do such work, if he wishes to make a favorable impression on the people in the house and leave the place in a most satisfactory manner to the occupants of it, must first prepare himself for the place he is to go to; not particularly on account of the work to be done, but on account of the people in the house. The fitter should never go to such a house with dirty clothing on; he may wear overalls, but they should be clean. He should, if possible, wear a white shirt and collar on such occasion, and not have his hands full of grease or dirt, but clean. He should have his hair nicely combed and his hat off in all such cases. He should walk around the house with ease, and never open a room door without first rapping or inquiring from some servant whether he could go into such room or not.

When he has completed on one floor he should always inquire from some servant or other person whether he can go to the next floor or not, and wait until he receives an answer before doing so. The fitter in doing such repairs often finds many things in his way which he must remove, and in such cases he should be very careful how he handles the articles he moves, and when the work is finished everything removed should be carefully replaced, so that the occupants of the house would not notice that such things had ever been handled. If the fitter requires some chair or anything to stand on, he should be very careful about what kind of chair he uses, if any, and should go and get it himself and not be continually annoying the people in the house to wait on him. The fitter in talking to the lady or gentleman of the house should be careful as to how he addresses them, and should simply and briefly answer the questions that he may be asked, and ask no questions himself. I might state that it is also a very good point for the fitter to have his shoes nicely polished, as an old shoe well polished makes a better impression than a new one that looks dirty. The fitter will have to be careful also in regard to the appearance and actions of his helper on such a job, as the man will be responsible for the boy's actions. This extra amount of care takes time, and in some cases it may cost the fitter a little extra expense; that may be so, but the people who are treated with such care will be perfectly satisfied to pay a little more. Such a careful fitter gets a better price for his work, and when there is anything else to be done at the house where the careful fitter once did some work, they will remember him and send for him with double confidence. The fitter should never allow a strange boy out of his sight while in such houses doing such work.

THE FITTER SHOULD NOT BLACKEN THE WALLS.

In doing work around gas fixtures that are in place, the fitter should be very careful about the walls and ceilings and not blacken them with his torch-light in cases where he has to heat a joint to wax it or for the purpose of disconnecting. He should have proper tools to do this work with, and in place of using kerosene or some other kind of oil in his torch he should use the best kind of alcohol, so that there will be no smoke from it to dirty the fixture or ceiling. In Fig. 76 is shown a proper gas fitter's torch, made in the best pos-

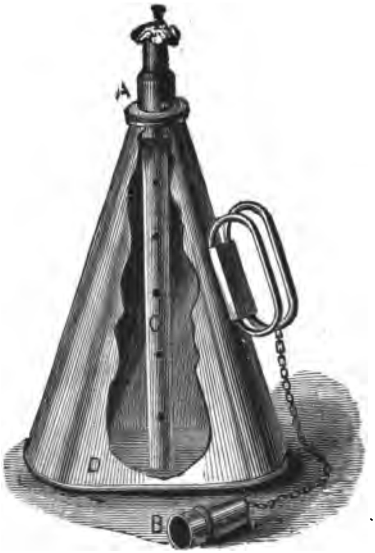


Fig. 76.

sible way of sheet brass, and having a perforated tube extending down to the bottom, which holds the cotton

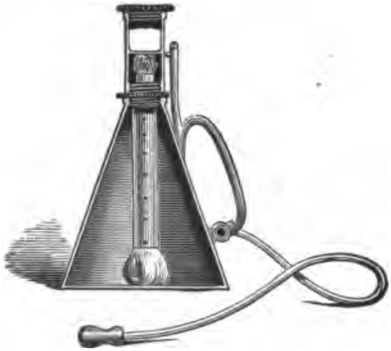


Fig. 77.

wick and keeps it in place. In Fig. 77 is shown still another kind of torch, which is a combination, having connected with it a blow pipe which is quite handy, inasmuch as the fitter who has this style of torch is always sure of having his blow pipe. The blow pipe on this torch, as shown in Fig. 77, has a small rubber tube attached to it, which makes it very convenient in many places. These torches, Figs. 76 and 77, are intended for small work, but where heavy heating is to be done, such as heating large gas fittings, the "Blow-Torch," as shown in Fig. 78, is best. This is a powerful heater and will answer for many purposes. These torches, as shown in Figs. 76, 77, and 78, are manufactured by the old and reliable E. P. Gleason Manufacturing Co., 181 to 189 Mercer Street, corner Houston Street, New York

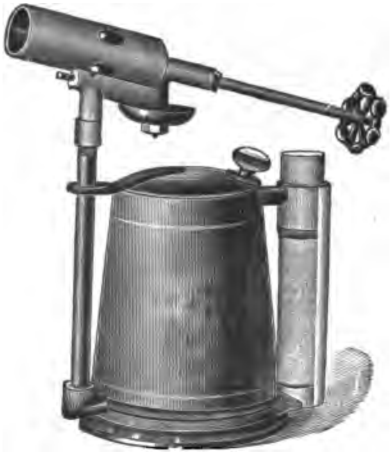


Fig. 78.

City, who were the pioneers of this country in the making of gas appliances, and are still up to date and in many respects lead in this line.

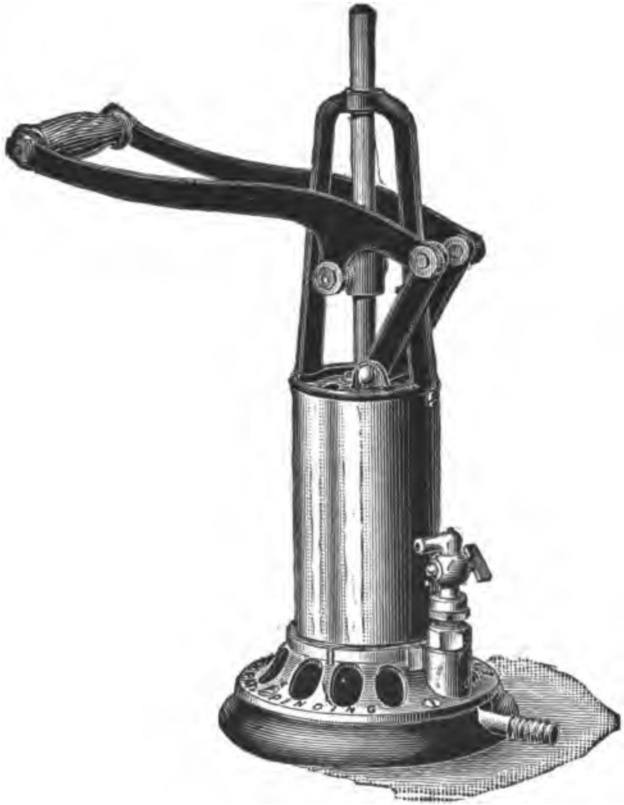


Fig. 79.

THE GAS FITTER'S PUMP.

The gas fitter will save considerable time by having a good proving pump, and the latest and best pump for this purpose, to my knowledge, is "McLean's Quick Service Air Pump," as shown in Fig. 79. Two or three strokes of the pump will fill an ordinary job of gas piping, and it is done with such ease, the parts being so well fitted, the principle of leverage which this pump has cannot help but be admired and appreciated by any mechanic of ability. This pump is also made by the E. P. Gleason Manufacturing Co.

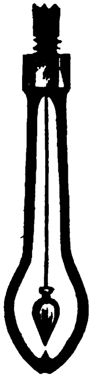


Fig. 80.

A NEW PLUMB-BOB FOR FITTERS.

A very fine little device in the way of a gas fitter's plumb-bob is shown in Fig. 80. By the use of this tool drops from ceilings can be made perfectly plumb and without guess-work, as will be noticed. The frame is cast in one piece and is cast iron, so that it cannot bend, having its upper end tapped out for ⅜-inch pipe, which tapping is centered to the point at its lower end, with a fine cord hung from the centre of the opening at top and a small brass plumb-bob at its lower end. All that is necessary to do is to screw the devise on to the drop or pipe to be plumbed and bring the pipe to a point where the plumb points to the centre part of the frame, and then fasten the pipe. This saves a large amount of time and besides makes a sure job every time. The device is known as Lawler's Plumb-bob. It is inexpensive and can be purchased from the leading dealers in gas-fitting supplies.

GET THE BEST KIND OF TOOLS.

I would like to impress upon the mind of the fitter the necessity of not only having the best kind of tools to do his work with, but to keep them in first-class order at all times. Good tools that are kept in good and proper order will earn more money for the fitter who has much work to do than a number of hands of a certain class whose names are on the weekly pay-rolls. Some slovenly fitters are very careless about the way they use and take care of tools. A good tool is worth taking good care of as well as a good man. Mechanics in other lines appear to take much better care of tools than the gas fitter. The carpenter knows how much easier and better he can do his work by having his tools in good order, and he is noted for being careful about them. The machinist cannot do much work in his line unless his tools are in the best of order; and it will be noticed that in all first-class machine-shops they are more particular about the tools than anything else. It is the best possible proof or indication of what kind of a mechanic a man is by noticing the order in which he keeps his tools. In the first place, it takes time and experience to know how to properly care for tools; and the man who does not handle with care and keep them in good order is either a man of little experience in his line, or he is too lazy and has no taste for anything neat, and therefore is not fit to be trusted with any good or particular work.

GET THE VERY BEST YOU CAN BUY.

My advice to the fitter in selecting tools would be not to look for the thing that is lowest in price, but the tool that is the best, if it is at all possible for him to buy it; it will be starting out in the right direction. Besides, with the best kind of tools work can be done much better, with greater ease and in very much less time. Good tools, like everything else good, will always bring a much better price in proportion to what they cost if sold after being used. The tools should be carefully kept together, and not allowed to be scattered all over the shop or building where the work is going on. The fitter, if he has a helper, should carefully instruct the young man how to keep the tools clean and together.

PUT YOUR TOOLS IN ORDER.

The gas fitter after completing the piping of a building, or any piece of pipe work, and having returned to the shop, the next thing he should do as soon as he has time to spare is to put his tools in shape. Fix any little repairs that they may need, and don't wait until they have gone too far to be repaired. Sharpen the tongs, tighten up any loose bolt or screw connected with the stocks, die, and cutters; sharpen the chisels and file the saws. Put them all in *the* best order at once, and do not wait until you are ready to start out on another job. This is where shop time can be well and profitably utilized.

BE CAREFUL ABOUT THE FITTINGS ALSO.

In doing gas fitting where the pipe and fittings are taken to the building to be cut and fitted, it will be necessary to use some judgment and care in regard to how the pipe and fittings are allowed to be kicked about the building, or carefully kept dry, clean, and together. This is another place where there is a good chance of loss to the fitter through slovenly and careless employees. It is a common thing to find any quantity of good sound gas fittings, nipples, and often many feet of good pipe among the sweepings from new buildings long after the fitter has completed his work and left the building. Now, the employee who allows this to happen is not doing right by his employer. He forgets that large numbers of these small fittings will amount to considerable, and when he is compelled to buy one or more he will find out that they cost something. In place of the fittings, if he saw what they cost in cash money lying about the building, he certainly would be more careful about picking them up. The fittings should be kept together and in a dry place, and not allow the rain to wet them and cause them to rust and look like old fittings, which they really would in a rusty shape; they should be placed where they would not be all daubed up with plaster or any other kind of dirt. It will be seen that where fittings are allowed to become dirty and rusty, there will be considerable time lost or time spent in putting them in fit shape to be used; therefore it is the fitter's duty to see that all fittings and pipe left over from a job are promptly brought back to the shop and placed in the bins where each size and shape belongs. There are many kinds of gas leaks, and I consider some of the things mentioned above to be among the worst and largest.

LIPPED UNIONS SHOULD NOT BE USED.

The lipped union is a bad fitting to use on gas pipes, and should never be used under floors or in plastered partitions, or in fact in any place on gas pipes if it is possible to avoid them. Where the fitter must cut out a piece of pipe under a floor or in some partition to make a connection with, or for any purpose in connecting up again, he should use the running thread connection and carefully heat and wax it, and not put in a union; because the washer of the lipped union soon dries up, becomes hard, and then leaks. This cannot happen with the long or running thread connection, which has no washer to act in that manner.

SEPARATE RISERS FOR EACH FLOOR.

In large buildings where each floor is piped separately, having its own independent riser, the fitter should wire to the bottom of all such risers a good tag, plainly telling what floor each belonged to, which will again save some time when the meter is to be connected.

TEST EACH FLOOR SEPARATELY.

Another place where considerable time can be saved is in the testing of pipes in large buildings; and that is, in place of connecting all the pipes in the building together and testing them at the same time, to keep each floor separated from the others, even where they are all to be supplied through one meter, and test each floor by itself, and after all the floors are completed and tested they can then be connected up. In this way there will be less running around and climbing from one floor to another looking for leaks; and, besides, the leaks can be found much quicker. It is a very hard thing to find small leaks when all the pipes in a large building are connected together. To find leaks in new gas pipes that are being tested there is used a small quantity of ether. It is poured into the pipes before the pressure of air is put on to them, and where a leak occurs it can be noticed by the smell of the ether escaping from the pipes. Soap-suds is also used to apply on the pipes where it is hard to find the leak. The fittings, joints, or parts of the pipe that we think leak are covered with soap-suds, and the leaks are discovered by the air bubbles formed from the soap-suds, which can be easily seen. When a number of such leaks are discovered such parts of the pipe or fittings are heated and waxed, and allowed to stand long enough until they cool and the wax becomes hard before the pressure of air is forced in again. This operation is continued until the pipes are found to stand perfectly solid and hold the pressure of air.

HOW TO PROPERLY SET THE METER.

Another quite important thing for the gas fitter to do properly is the setting of the meter. The fitter who sets a gas meter should first prepare a suitable shelf for the meter to stand on. The shelf should be solid, well secured to the wall, and set perfectly level. Never hang up a meter without resting it on a proper shelf. Where meters are simply hung to the pipes their own weight soon bends the connections out of shape and often breaks them off. All meters should have meter cocks on the inlet connection so that the meter can be disconnected without danger. The meter cock should have a key on it, so that the gas could be turned off at short notice in case of a leak, and it should be located in a place that would be easy of access even at night time without a light.

KEEP A CLEAR PASSAGEWAY TO WHERE THE METER IS LOCATED.

Never block up the corner or part of the cellar where the meter is located with wood, step-ladders, pieces of old furniture, or anything else.

THE GAS METER CANNOT EXPLODE.

When the gas meter is properly connected and the gas turned on there is no danger of it blowing up, even with a light near it. All that could happen in such a case would be to ignite the gas that might be escaping from some leak, the same as to light the gas escaping from a leak in a small gas pipe, but the fitter should be very careful about how he handles the meter before it is connected to the pipes. There is more danger in the gas meter before it is set than when it is in actual operation. Gas meters, as a rule, are tested when new with illuminating gas, and meters are often changed from one building to another, and after being disconnected part of the gas that they had at the time still remains in them until after they are connected again. Therefore, it might be considered that any gas meter having once had gas in it has always afterward a certain amount of gas remaining in some parts of the bellows, and this is the reason why the fitter should be careful about how he handles the meter before it is connected. Never place a light near its open connections. Gas when mixed with air makes a powerful and most dangerous explosive. By handling the gas meter and then setting it down the bellows are caused to move to some extent, and when they move a current of air is produced by the suction of the bellows. Now, to hold a flame to the inlet under such circumstances the flame would be drawn into the meter and the result would be an explosion. I have tried this and found it to work to perfection. It nearly blew up the building, and the janitor had a narrow escape from being struck with one part of the meter which came within a few inches of his head. I would advise the reader not to try this experiment, but take my word for it. Ever since I have been more afraid of a gas meter with no pipes connected to it than one in operation.

CONNECTING OR DISCONNECTING GAS PIPES WITH THE FLOW OF GAS ON.

The gas fitter is often called upon to make some connections with gas.pipes where the gas cannot be turned off, such as the laying of service pipes in ditches, vaults, areaways, and many places outside of the meter cock, and in such cases he must act with the greatest care, as it frequently happens that gas fitters in making such connections are overcome by the escaping gas, and in many cases it proves fatal. Therefore, when such a piece of work is to be done the fitter should have everything ready in the best possible shape, so that the work can be done as quickly as possible. He should not have to wait for anything, and one man should never go to do such a piece of work alone; he should in all such cases have some assistance in doing the work, and also if possible some other person near by who can see them as the work is being done.

THE WELSBACH GAS BURNER.

To show that gas is holding its own in the way of improvements in burners, I would respectfully call the attention of the gas fitter to the "Welsbach Burner," cuts of which are shown in Figs. 81 and 82. It is manufactured by the Welsbach Light Company, of Gloucester City, N. J. This burner makes a wonderful step forward in the line of improvements and opens up a new field of work, which I am satisfied will result in still greater improvements. The Welsbach burner is in appearance something like the ordinary "Argand" burner, having a similar shade and chimney, but the way the light is producced in the Welsbach burner is quite different to the flame or light in the old style Argand burner.

In Fig. 81 is shown the Welsbach burner in section, and in Fig. 82 is shown the burner complete with shade, as it appears when applied to a gas fixture. The light

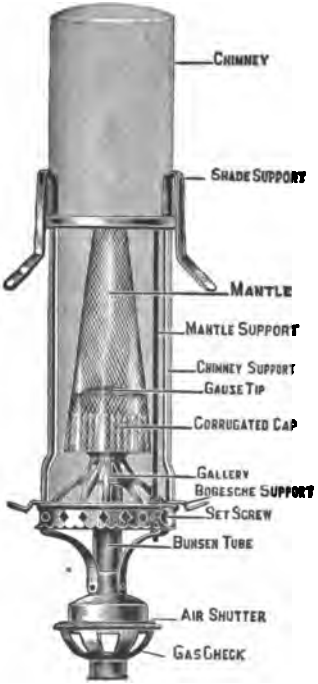


Fig. 81.

from this burner is not directly from the flame, as is the case with most all ordinary gas burners, but from the intense heat of the mantle which is heated by the flame; in other words, we get the light through this burner from the gas in an indirect way. This burner works on the "Bunsen" burner principle; it draws air in, which it mixes with the gas and gives a more intense heat, which

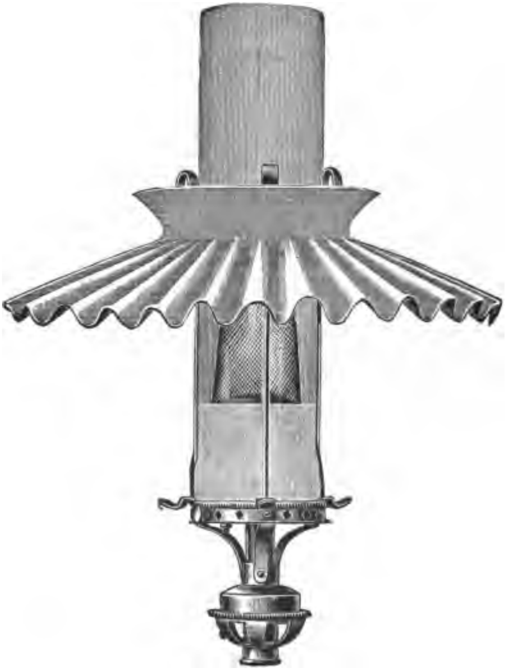


Fig. 82.

is wanted in this case. The material used in the mantle is something similiar to that used in the incandescent electric lamp. This burner gives a beautiful light and works equally well with all kinds of gas.

THE FIELD WIDENING FOR THE UTILITY OF GAS.

Gas is no longer confined alone to illuminating purposes, but is now used for every purpose that fuel of any other kind is used. We have to-day most perfect cooking stoves and ranges that use gas as the fuel, and so perfectly do they work that there is not the slightest notice of any disagreeable odor from the gas. Gas is now used as the fuel for hot-air furnaces in the heating and ventilating of houses; it is also used to heat water for various purposes for domestic use. All the leading tin-shops use gas as the fuel to heat their soldering irons in place of the old style charcoal furnace. There are many large printing houses and even manufacturing establishments that use gas engines to furnish the power they require; in fact, there is no place where fuel is required that gas cannot be used.

GAS WELLS.

Recent developments in the matter of drilling gas wells have brought to light many important facts that a few years ago were altogether unknown, or if advanced by the theorist were scouted at as theories only, impracticable for actual use. The deeper gas is obtained, the greater natural pressure it will gather. Natural pressure being the most desirable object as a means of conveying the gas from the source of supply to the place of consumption, it is necessary to prevent the deep-well or high-pressure gas from escaping through the open, porous rock near the surface, where it would pack this porous strata, lose its pressure, and escape at a distance from the well wherever it could find an outlet. The modern method of treating a well is to case below the water and tube to the top of the rock where the high-pressure gas is found, place a packer at this point, and thus shut off all communication with the well above the packer.

With a casing head opening from both tubing and casing, you have at once two distinct veins of gas at hand.

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PERFECT COMBUSTION.

Perfect combustion in an atmospheric or Bunsen flame is the result of mixing the proper amount of air with gas to obtain a greenish-blue flame without the attendance of smoke or carbon. Experiments have shown that the proportion of air and coal-gas are about 6 volumes of air to 1 volume of gas, and 10 volumes of air to 1 volume of natural gas. It will readily be seen that it is more difficult to obtain perfect combustion at a very low pressure (say 1 inch water pressure) with natural gas than with coal or illuminating gas. But tests have shown that with the proper arrangement of burner, mixing tube, mixer and jet, it is a simple matter, but not on the theory of a great many stove-makers, that "any kind of a burner will burn natural gas." Perhaps any kind of a burner will burn natural gas at 4 ounces, but not at 1 inch water pressure.

VALUE OF A GIVEN QUANTITY OF NATURAL GAS AT DIFFERENT PRESSURES.

Cubic feet.	*Pressure.*	*Per cent.*
100	4 oz.	100
100	8 "	104
100	16 "	106
100	1½ lbs.	109.1
100	2 "	111.8
100	5 "	125
100	10 "	140
100	15 "	200

Theoretically, 30,000 cubic feet of natural gas is equivalent to one ton of bituminous coal.

ANALYSIS OF DIFFERENT GASES.

	Natural Gas, about 10-Candle Power.	Siemens Producer Gas. No Illuminating Power.	Water Gas, 22-Candle Power.	Coal Gas, about 16½-Candle Power.
Oxygen	.80	.00	.06	.00
Hydrogen	22.00	6.00	37.20	46.00
Marsh gas	67.00	3.00	18.18	39.50
Carbonic oxide............	.60	23.60	28.26	7.50
Carbonic acid	.60	1.50	.84	.70
Nitrogen	3.00	65.90	2.64	.50
Illuminants	6.00	.00	12.82	5.80
	100.00	100.00	100.00	100.00
Approximated weight per 1,000 cubic feet in lbs....	38.20	69.90	40.70	35.28
* Heat units per cubic foot.	789.00	114.00	650.00	674.00

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* A unit of heat is the amount of heat necessary to raise the temperature of 1 lb. of water 1 degree Fahrenheit.

FLOW OF NATURAL GAS—SPECIFIC GRAVITY 65—THROUGH ONE-INCH CIRCULAR ORIFICE.

Pressure, Inches Water.	Cubic Ft. per Hour.	Inches, Mercury.	Cubic Ft. per Hour.	Pressure, Lbs. per Sq. Inch.	Cubic Ft. per Hour.
2	2,041	1	5,168	5	17,186
4	2,897	2	7,632	6	18,989
6	3,542	3	9,305	8	21,778
8	4,116	4	10,552	10	23,388
10	4,563	5	12,019	12	25,479
..	.....	6	13,220	15	27,876
..	.....	7	14,182	20	33,027
..	.....	8	15,316	25	38,002
..	.....	9	16,025	30	42,762
..	.....	10	16,970	35	48,074
..	.....	..	......	40	52,761
..	.....	..	......	50	62,352
..	.....	..	......	60	71,125

MULTIPLIERS FOR LARGER ORIFICES.

2 in.	4	5 in.	25	8 in.	64
3 "	9	5⅝ "	31.00	10 "	100
4 "	16	6 "	36	12 "	144

HEIGHT OF COLUMN OF LIQUID TO PRODUCE ONE POUND PRESSURE PER SQUARE INCH AT 62 DEGREES TEMPERATURE.

Water	27.71
Machinery oil	30.80
Mercury	2.04

COMPARATIVE VALUE OF COAL, OIL, AND GAS.

In the best practice, with boilers of proper construction and proportioned to the work—

1 lb. of coal will evaporate 10 lbs. of water at 212 degrees atmospheric pressure.

1 lb. of oil will evaporate 16 lbs. of water at 212 degrees atmospheric pressure.

1 lb. of natural gas will evaporate 20 lbs. of water at 212 degrees atmospheric pressure.

1 lb. of coal will equal. .... 11.225 cu. ft. of nat. gas.
2000 lbs. of coal (1 ton) will equal .. 22,450.00 “ “
1 lb. of oil will equal........... 18.00 “ “
1 bbl. of oil (42 gals.) will equal. 5,310.00 “ “
1.125 cu. ft. of nat. gas will evaporate 1 lb. of water.
1 “ “ “ equal.. 860 B. H. U.
1000 “ “ “ “ .. 860,000 “
1 ton of coal will equal .... 19,307,000 “
1 bbl. of oil “ .... 4,566,600 “

In ordinary practice, about twice as much fuel is required to do this amount of evaporation.

THE EQUIVALENTS OF OUNCES IN WATER AND MERCURY.

Ounces.	*Inches of Water.*	*Inches of Mercury.*
1	1.7	.125
2	3.4	.250
3	5.2	.375
4	6.9	.500
5	8.6	.625
6	10.3	.750
7	12.0	.875
8	13.8	1.000
9	15.5	1.125
10	17.2	1.250
11	19.0	1.375
12	20.8	1.500
13	22.5	1.625
14	24.2	1.750
15	26.0	1.875
16	27.7	2.000

ADDENDA.

A SOFT COAL STEAM AND HOT-WATER HEATER.

The Gorton Soft Coal Boiler which we illustrate is especially constructed to burn the soft coal which is so abundant in the Southern and Western States.

From the tendency of soft coal to deposit soot and unconsumed carbon on the heating surface of the boiler in which it is used, it has given so much trouble that its use in house heating boilers has been rendered far from being economical in spite of its cheapness.

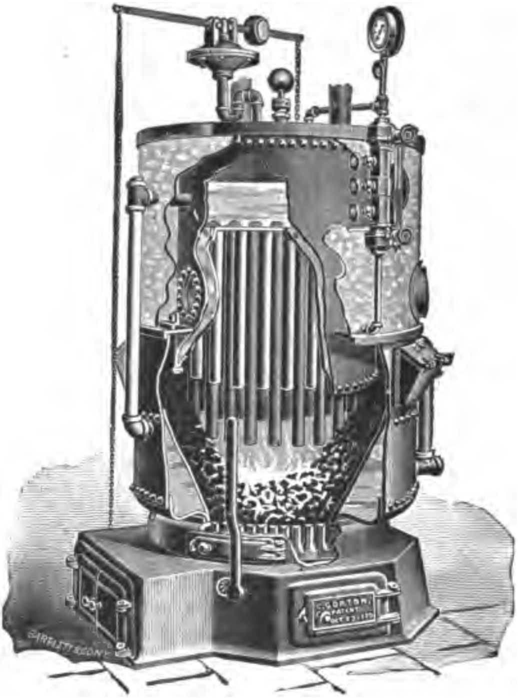
The thick black smoke which deposits its soot and unconsumed carbon on the heating surface of the boiler is caused by imperfect combustion, and ceases when perfect combustion is attained.

Take for an example the mechanical stoker now being used to a large extent for supplying coal to power boilers. By its use even the finest soft coal can be continuously fed into the fire-box without visible smoke from the chimney-top, which shows that complete combustion is obtained by the more uniform feeding of the coal to the furnace than when the fire is fed by an engineer.

Instead of using a mechanical device for supplying coal to the fire-pot of the Gorton Soft Coal Boiler, it is accomplished by *gravity*.

The coking chambers and coal reservoirs are located between the lower outer surface of the boiler and the upper part of the water leg, so that the coal feeds down into the fire just as it is required.

The fire-pot of this boiler is so constructed that sufficient additional air is drawn through the fingered ring at the lower edge of the coking chambers to ignite the gases arising from the coking process. This gives perfect combustion, which means economy in fuel, and pervents the deposit of soot and unconsumed carbon on the heating surface of the boiler, and makes use of that part of the fuel which is wasted when soft coal is used in ordinary fire-pots.



Gorton Soft-coal Boiler.

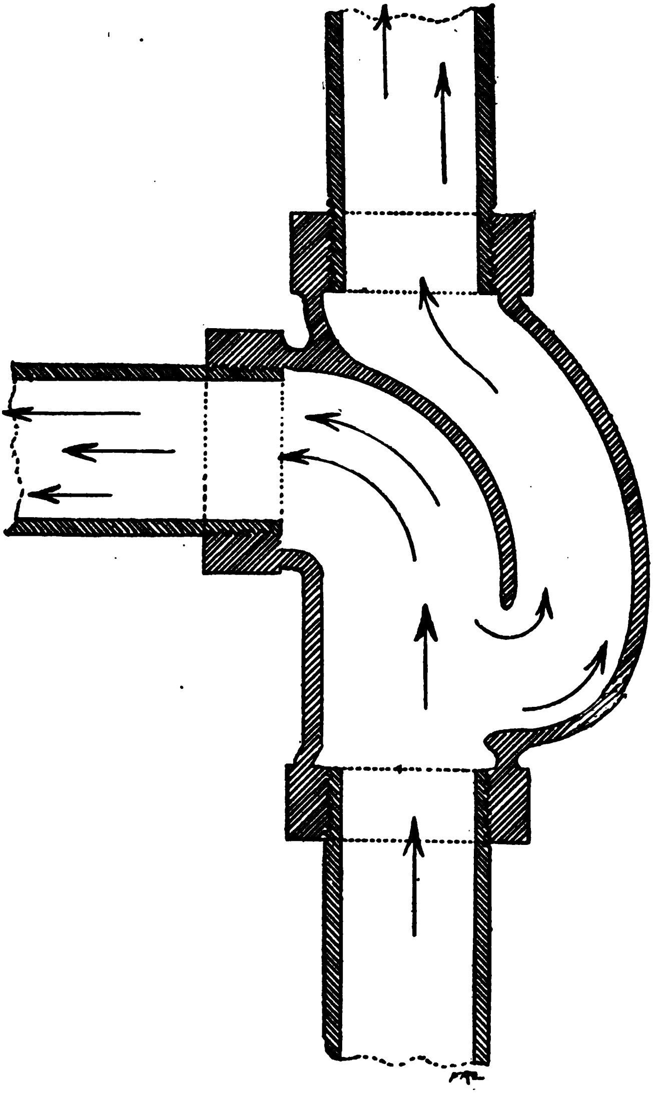


Fig. D.

NEW SPECIAL HOT-WATER DISTRIBUTING FITTING.

ONE of the latest special hot-water fittings is shown in Fig. D. This is called a distributing fitting, and is specially intended to be used on vertical lines of flow pipes in place of the old style tee. As will be noticed by referring to the cut, it is divided by a web forming two separate channels for the water through the body of the fitting. This fitting is supposed to give less resistence to the flow of water, and at the same time causing the hot water rising from the heater to move through the side outlet with as high a temperature as that which flows through the upper or highest outlet of the fitting, thus distributing the hot water with the same temperature to the various radiators on the different floors. Another special point claimed for this fitting is that it accomplishes the same work with better results than that accomplished by the connection made with an ordinary Y fitting, nipple, and elbow, which are often used on risers.

ACETYLENE:

HOW GENERATED AND HOW USED.

BY GEORGE T. HANCHETT, S.B., M.A.I.E.E.

Acetylene is a light, colorless gas, which is so easily and cheaply generated and controlled and burns with such brilliancy that it bids fair to replace many existing illuminants. The fact that it can be generated and used in small plants—in fact, from one-light capacity up—has combined with its other advantages to make it very popular and worthy of discussion in a book of this character.

Acetylene is not a new gas, having for a long time been known to chemists. It was discovered by Edward Davy in 1836 and by him introduced to the notice of the British Association. Its chemical symbol is $C_2 H_2$; that is to say, each molecule of acetylene contains two atoms of carbon and two of hydrogen.

This new illuminant is usually produced by the union of water and calcium carbide, and for many years the production of this carbide was a chemical process of such difficulty that its price was prohibitive for almost every commercial use. Only recently has a relatively cheap process been devised. The process is interesting and is worthy of a paragraph.

The carbide is formed under the intense heat of the electric arc. A furnace is formed by a little metal truck, to which one wire of the source of electric supply is attached. The other terminal consists of a very large carbon rod, which is suspended over the truck by a chain, by which it can be raised and lowered. The source of electricity is usually an alternating current at from 100 to 200 volts pressure and of almost unlimited current capacity.

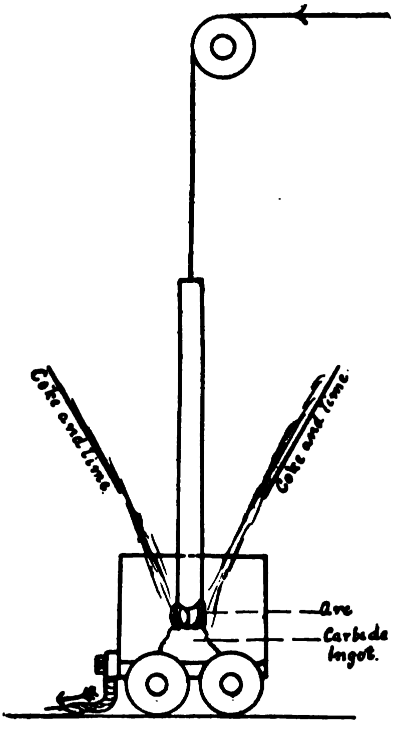


Fig. 1.—Diagram of carbide furnace.

The heavy carbon rod is lowered into the bottom of the truck and a powerful arc, some six or eight inches in length, is drawn, which, on account of the alternating current, sets up a deafening roar. A diagram of the truck and carbon is shown in Fig. 1. From the chutes on the sides are poured intimate mixtures of powdered coke and lime, mixed in the ratio of 40 and 60 per cent. respectively. Under the intense heat, the calcium of the lime and the carbon of the coke unite to form calcium carbide, which forms in a button under the carbon rod. This button builds up as the process continues till it becomes an ingot often weighing as much as 150 pounds, and this ingot is allowed to cool, and, being dusted free from surplus coke and lime, is crushed in a breaker and packed for market.

In appearance the carbide is a grayish mass, presenting a steely ore-like fracture when broken. It has a great affinity for water, but, aside from this, is a very stable compound. It is not explosive and submits passively to either heat or concussion, but because of its great affinity for water, it must be kept in water-tight receptacles. It is usually sold in cans, or, in larger quantities, in steel drums, which are returnable. The present demand for carbide is so great that the two large factories at Niagara Falls and Sault Ste Marie are working night and day.

If we drop into water a piece of calcium carbide we shall find acetylene is promptly and abundantly generated. It will be recognized by its pungent odor and by the fact that the bubbles rising to the surface burn with a smoky flame. It is found that about five cubic feet of gas is produced by the union of one pound of carbide with sufficient water. At the close of the experiment there will be found in the bottom of the vessel a whitish yellow powder, which is slacked lime. The chemical reactions are as follows:

Name of Substance,	Calcium Carbide.		Water.		Unslacked Lime.		Acetylene.
Chemical Symbol,	C_aC_2	+	H_2O	=	C_aO	+	C_2H_2
Relative Weights,	16 oz.	+	4½ oz.	=	14 oz.	+	6½ oz.

This being the reaction when just enough water is added to free the acetylene.

If an excess of water be added, the lime will be slacked and the reaction becomes

Name of Substance,	Calcium Carbide.		Water.		Slacked Lime.		Acetylene.
Chemical Symbol,	CaC_2	+	$2H_2O$	=	$Ca(OH)_2$	+	C_2H_2
Relative Weights,	16 oz.	+	9 oz.	=	18½ oz.	+	6½ oz

The process of generating acetylene forms considerable heat, about 900 British thermal units of heat to the pound of carbide, and it is necessary to take account of this heat in building a generator. Acetylene is a delicate gas in the presence of heat and tends to split up into other hydrocarbon gases, which are inferior in illuminating power and even a positive detriment.

This process, which is sometimes called polymerization, is accompanied with the production of semi-solid matters which clog the burners and pipes. The gas begins to break up at 150° F. and at 400° F. is practically destroyed for lighting purposes. Temperatures as high as 1,353 degrees have been reached by the union of carbide and water in confined quarters, and hence in the construction of a generator means for conducting away the heat is very important.

It is now easy to see that a good equipment for acetylene generation must possess the following characteristics:

1. It must deliver the gas to the burners at a steady, even, moderate pressure.

2. It must not heat the gas over 140° F. in the generation.

3. It must cool the gas and thereby condense the watery vapor contained.

4. It must provide means for conveniently charging

with carbide and removing the lime without interfering with the gas supply.

5. It must economically consume all kinds and sizes of carbide.

6. The burner must be of such a character as to thoroughly burn the acetylene and produce its brilliant white light.

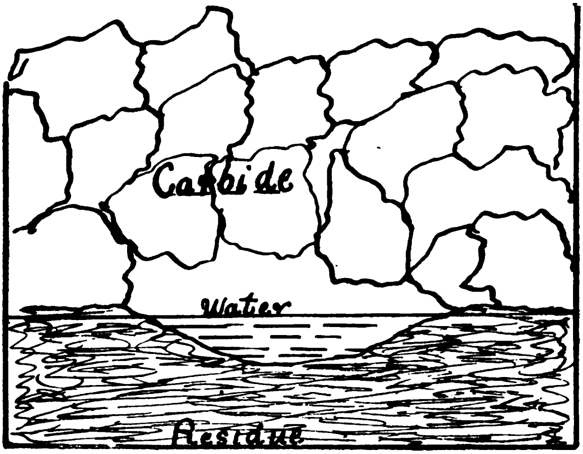


Fig 2.—Showing how by collapse of arch a large body of carbide and water may be brought together.

All of these requirements are difficult and many devices have been produced to meet them, all of which are more or less effective. Acetylene generates from carbide very rapidly upon its contact with water, and the problem has been whether to add the water to the carbide in small or large quantities or whether to add the carbide to the water. The last process, of dropping the carbide in the water, offers many advantages as far as generation is concerned, but it is difficult to arrange automatic means to accompli this reliably, and hence the majority or acetylene generators control the water supply to the carbide.

If the carbide is dropped into the water piece by piece the generation of gas ceases quite abruptly with the flow of carbide and the volume of water makes the process cool.

If, on the other hand, the water is allowed to drip on the carbide, generation does not cease with the flow of water, but continues at a reducing rate, due to the water absorbed into the lime and the mass as a whole. Frequently the action takes place as shown in Fig. 2, the water forming in a little pool under an arch of carbide and lime, which, as the process continues, suddenly collapses, bringing quite a volume of carbide and water together and causing a flush of gas which the governing devices did not call for. In short, the gas generated thus is spasmodic in its flow, and as the consumption is moderately steady, means must be provided for storing or otherwise disposing of the surplus.

GENERATORS.

The first generators contained the carbide in a strongly made vessel, and water pressure from the city mains was admitted via a check valve. A pressure of gas was produced which quickly shut the check valve, but even after the water flow ceased gas continued to be generated and was stored under pressure. The pressure often reached very high figures. From this vessel the gas was tapped off to a governing device of some sort which delivered the gas to the pipe system at a suitable pressure for burning. When the initial pressure in the main receptacle was sufficiently reduced, water again forced by the check valve repeated the process.

A serious objection to this system is the high pressure in the primary generator, and sometimes, owing to failure of the governor, the excessive pressure was impressed upon the piping system, which burst under the great stresses and thereby gave rise to many unfounded rumors that acetylene was explosive. Bursting would have taken place with nothing more harmful than ordinary air under such pressure. The combined action of heat of generation and heat due to compression called for great ingenuity of design to prevent the gas being damaged by overheating.

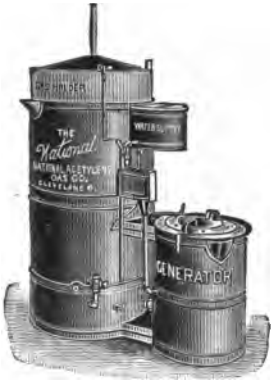


Fig. 3.—The National Dry Process Generator.

So little water was used that the limy deposit was taken from the generator quite dry and only partly slacked. Inasmuch as this type of generator is now used but little, it is unnecessary to more than mention it.

Most of the generators made to-day are on a low pressure system, and if the pressure exceeds a predetermined amount, usually two to four inches of water, the gas bubbles through a water seal and escapes. Of course this wastes gas, and a good generator uses the water seal very seldom.

A typical generator of this type is shown in Fig. 3. The carbide is placed in the generator and the admission of water thereto is controlled by the rise and fall of the gas holder which manipulates a valve by means of the attached rod. When the holder descends water is sprayed on the carbide, which promptly generates sufficient gas to send the holder up again and shut off the water. The carbide is placed in the generator in thinly distributed layers and sprayed over from many jets, the object of which device is to keep the machine sufficiently cool. Generators of this type which do not thus provide for the heat in some way are likely to overheat and polymerize the gas they generate. The valve handle which cuts off the generator from the gasometer interferes with the generator cover in such a way as to prevent its being opened unless connection is cut off, a very necessary precaution to prevent a back rush of gas from the gasometer. The capacity of the gasometer is considered sufficient to supply the lamps while a charge is being renewed. The residuum is taken from this generator in a dry state. This has been objected to by some, who state that the carbide cannot be as fully decomposed as when it is thoroughly wet at the end of the process. Careful design can, of course, minimize and possibly eliminate this difficulty, and the writer may add that he has often secured unconverted lumps of carbide from residue that was soaking wet, the unconverted carbide being well protected from moisture by a heavy coat of lime. Certain it is that whatever the system, waste will ensue if careless design is not avoided.

The generator illustrated in Fig. 4 is also constructed on the drip principle. The carbide generator is submerged in water, thereby making the operation very cool. It is a very cleanly machine in the matter of charging. In fact, this is its feature. The carbide comes packed in metallic cans, with automatic valve on top, which fits in corresponding part of the machine. By placing the can against

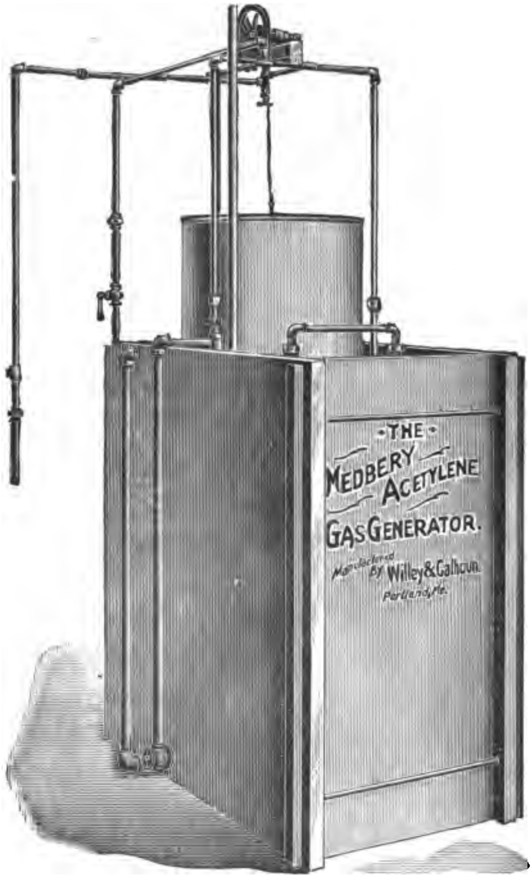

THE
MEDBERY
ACETYLENE
GAS GENERATOR.
Manufactured By Willey & Calhoun.
Portland, Me.

Fig. 4.—The Medbery Acetylene Generator.

the valve and giving it a turn the can is locked on. To remove the can it is given half a turn, which releases the machine and locks the valve on top of the can, thus preventing an escape of gas from the residue. This operation also turns the water off, the arrangement being such that it is impossible to connect the can to the machine without opening it and turning the water on, and conversely it is impossible to remove one without closing it and turning the water off.

This method is commendable because it is eminently fool proof and the handling of carbide and residue is entirely avoided. When one can is used up it is removed and a new one is put on and the exhausted can is thrown away. The can, however, figures as an item in the cost of the carbide, but by some the advantage gained would be considered a liberal equivalent.

Another generator, known as the Chautauqua acetylene gas generator, is built on the water dripping principle and has two carbide holders. The flow of water to the carbide holders is controlled by the gasometer bell, which by a suitable linkage manipulates a plug cock. The carbide holders are attacked successively by the water and as soon as one is exhausted automatic means are provided to switch the flow of water into the other holder. The principal feature of this generator, which renders it different from many others, is the provision for reserve capacity to take care of excess generation when all the gas jets are shut off. The gasometer bell is of liberal dimensions and the manufacturers state that it alone would be able to take care of excess generation, but additional means to store gas are also provided.

Within the gas holder is placed a steel receptacle which is made as large as compatible with space for a proper water seal for the bell. This cylinder is a storage tank and is made of heavy steel boiler plate riveted to a gas-tight joint and tested to a pressure of 100 pounds to the square inch. It is fitted with a safety valve, which blows off at 10 pounds to the square inch. Its operation is as follows: If the lights are extinguished and the excess generation continues till it fills the bell, a suitable lever attached thereto closes the feed pipe to the gas holder and diverts gas to the storage tank, where it is stored under pressure. If the pressure exceeds 10 pounds to the square inch it blows off through the safety valve. When the lamps are turned on again and consumption of gas begins

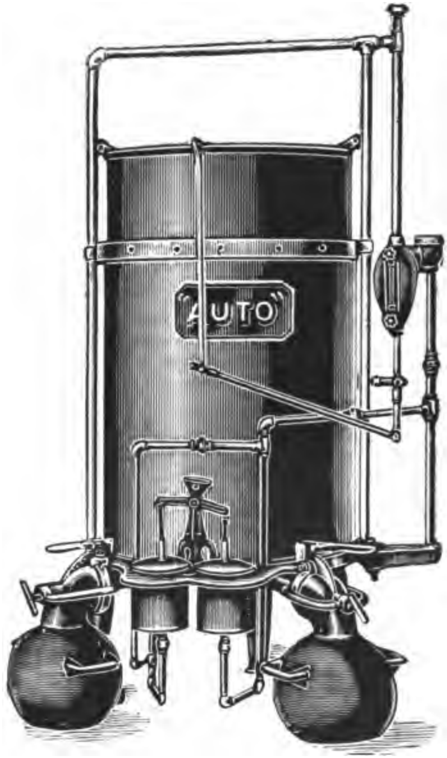


Fig. 5.—Drip principle generator; two carbide holders.

the bell sinks and allows the gas from the pressure chamber to pass into the gas holder, when the bell rises again. In this way the bell continues to draw on the reserve pressure supply until that is exhausted, and then, sinking a little lower, it turns water into the carbide holders and more gas is generated. The water levels in the various parts of this apparatus are observed by gauge cocks, no glass gauges or windows being used.

Another type of generator, which is of the class just mentioned but differs in detail, is depicted in Fig. 5. In this generator there are two carbide holders which are brought into play successively. Water is admitted to the flasks by means of a swinging tube, which is raised and lowered above and below the supply level by the gasometer bell. When the tube is lowered sufficiently, due to lack of gas in the bell, water drips from the swinging tube into the little funnel, which in turn drips it into one of the receivers, whence it flows via a loop lock into the carbide chamber. Here it is suitably distributed over the mass of carbide so as to produce minimum heat, and the gas which is generated raises the bell and cuts off the water. In passing into the gasometer the gas enters a condenser, which cools it and dries it by condensing the watery vapor it contains. When a carbide holder is exhausted the water continues to drip till it fills it and raises a float in the cylindrical receptacle, which tilts the funnel so as to discharge into the cylindrical receptacle of the other holder which is thus thrown in action. The first can then be removed and recharged without at all interfering with the action of the apparatus, and the angle at which the distributing funnel is tilted shows at once which holder is in action. The holders are so constructed that it is impossible to remove them without first cutting off the gas to the holder, and a water seal is provided to prevent excessive pressure.

Another generator of this type is shown in Fig. 6, a diagram which plainly shows the principle. The water is controlled by a swinging pipe attached to the gasometer bell, as with the "Auto," but the arrangement of the carbide holders, D_1 and D_2, is different. Water advances through a water trap to D_1, and, having exhausted it, backs up still higher and attacks the carbide contained in D_2. D_1 may then be cut off and filled while D_2 supplies the system. It will be found advisable to interchange D_2 and D_1 after the latter is renewed, for if D_1 is put on in its original position the water will leave D_2 and reattack D_1, and if they are never interchanged D_2 will become exhausted without due notice and cease to act as a reserve.

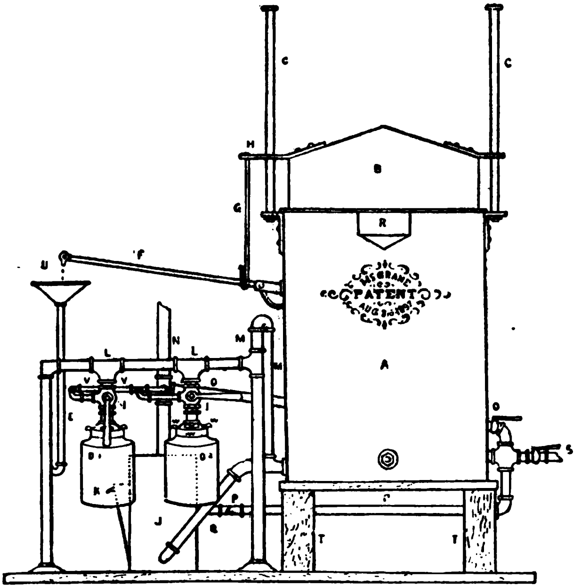


Fig. 6.—Drip generator; two carbide holders, one overflowing into the next.

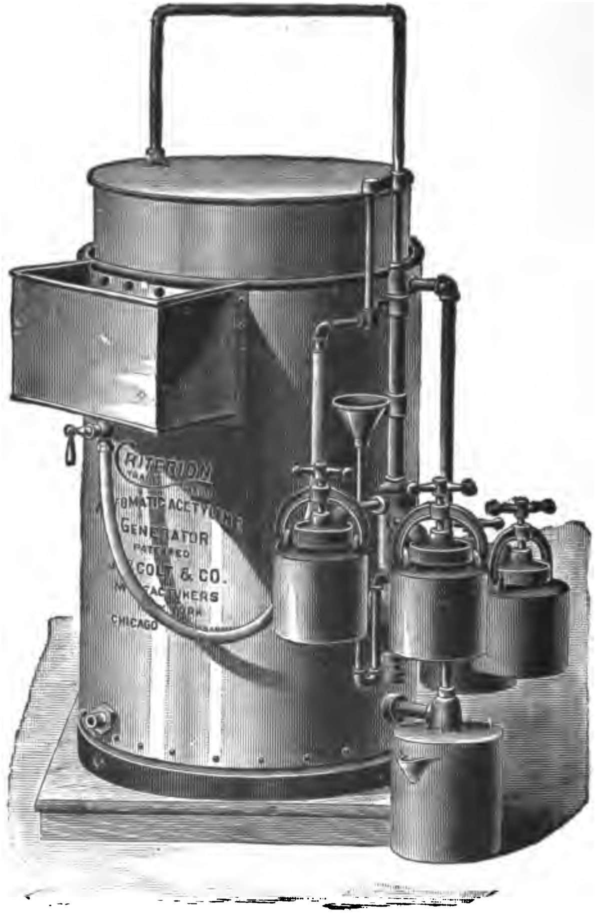


Fig. 7.—Drip generator with four carbide holders; the water backing up from the lowest to the highest.

Attention may be called to the fact that there is no means shown to indicate when D_1 is exhausted, but such a device is simply provided for by placing a float in the funnel U. The cut-off valve handle of the carbide holder is so shaped that it must be turned off before the holders are taken off, thus preventing a back flow of gas from the bell. The water seal Y also acts as a receptacle for condensation, which serves to keep its level constantly at the overflow K.

Another form of generator similar in principle to that just described, but differing in detail, is shown in Fig. 7. The carbide holders are attached at varying heights on a common standpipe into which the water drips, the supply being controlled by the gasometer bell, which raises and lowers the discharge spout above and below the level in the water tank. The water attacks the carbide in the holders in the order of their height, completely filling one holder before it backs up to the next. From the holders the gas passes to the water seal or wash bottle below, where ammonia and other soluble gases are washed out and the gas is cooled and dried by the condensation of the moisture it contains. The condition of the holders can be observed by tapping them, and the sound will denote whether the holder is full of water or not, a method which may be used on any machine of this type.

Another form, by the same maker, shown in Fig. 8, provides two sets of carbide holders which can be worked independently of each other, but is in other details the same.

In still another form, the subject of Fig. 9, the carbide holders dispense with gaskets and instead use a water seal. The top holder is filled first and overflows into the next and so on. This arrangement has an advantage in that one can see at a glance what holders have been exhausted. In very large sizes the J. B. Colt acetylene generators provide a separate pillar, around which the carbide holders are stacked. Such a set is shown in Fig. 10.

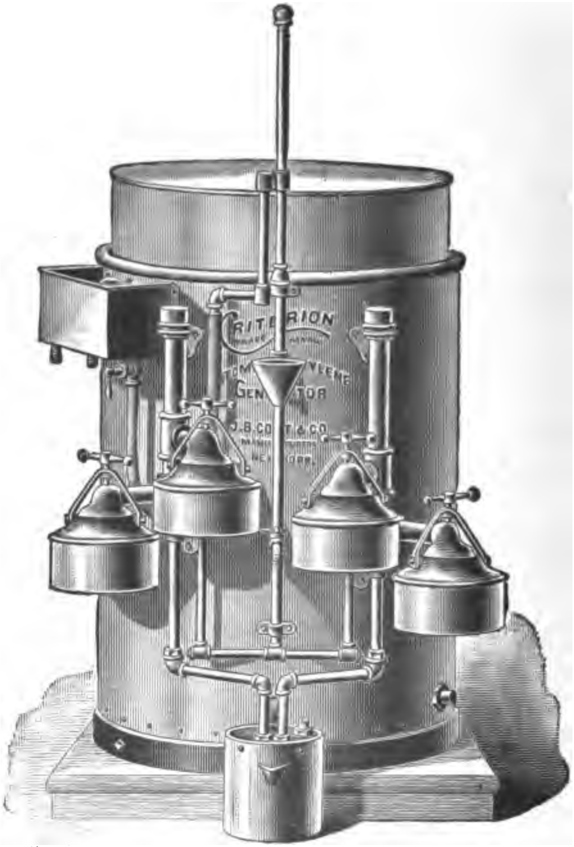


Fig. 8.—Drip generator, standpipe principle, with two independent sets of carbide holders.

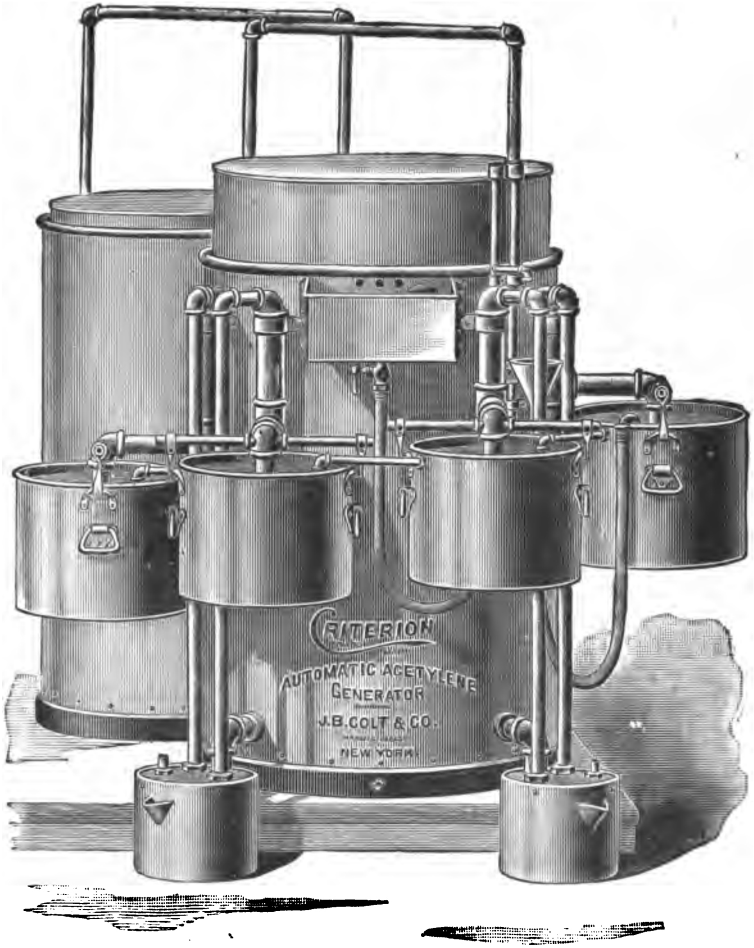


Fig. 9.—Drip generator on the overflow principle, the carbide holders being closed by water seals.

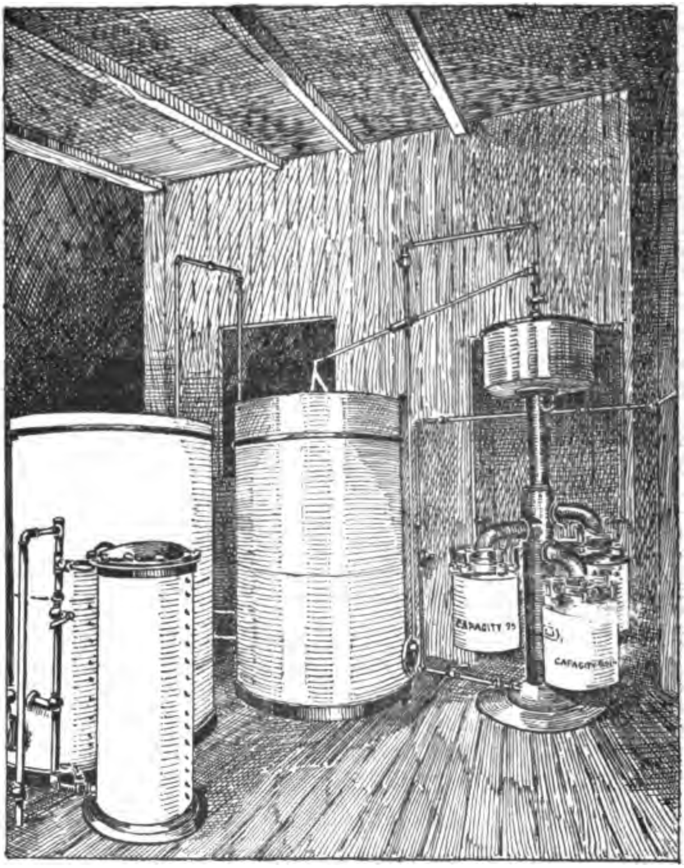


Fig. 10.--Large drip generator with carbide holders and water supply tank on a separate standpipe.

The generators just described belong to what has been called the water dripping class and constitute perhaps the majority of those on the market. Their great advantage is that they can use all kinds and sizes of carbide. There are, however, numerous other generators which operate on different but quite as effective principles. Prominent among these are generators operating on the "displacement" principle. This is very prettily illustrated by the simple apparatus shown in Fig. 11 and which is due to the *Scientific American*. The carbide is piled on a little rack supported platform fashion on four legs. It is placed in a pan and over it is inverted a common tumbler. A similar tumbler is inverted in the pan closely adjacent and the two are connected by a U tube. A third tube, provided with a stopcock, is bent and inserted as shown in the figure, and filling the pan with water completes the apparatus. When the stopcock is opened the water rises in both tumblers and presently comes in contact with the carbide, which instantly generates acetylene and forces the water back. As long as gas is drawn from the stopcock the water will rise again, and again be forced back, but when the stopcock is closed the water will remain permanently out of contact with the carbide and the generation of gas will practically cease. This system presents many advantages. The carbide can be installed in large quantities, as the use of the large body of water makes the process inherently a cool one, and, moreover, the lime residuum falls to the bottom of the pan, leaving fresh carbide surfaces to be attacked. This makes the device consume the carbide very thoroughly. With the drip type of generator the water has to be very ingeniously applied to prevent the action shown in Fig. 12, where the carbide is protected from the water by the residuum of lime. Calcium carbide is worth five cents a pound, and therefore it pays to examine the residuum a generator makes for free carbide. As it is quite difficult to recover carbide from residuum, and, in any event, is a nasty process, such free carbide is practically wasted.

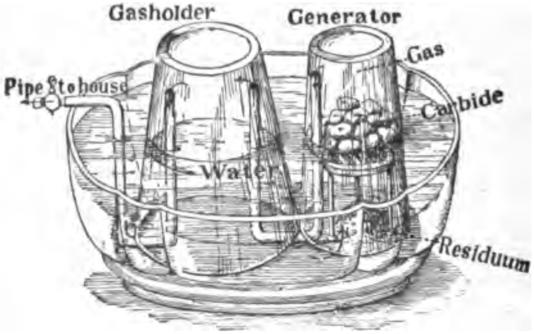


Fig. 11.—Principle of "clean surface" or displacement generation.

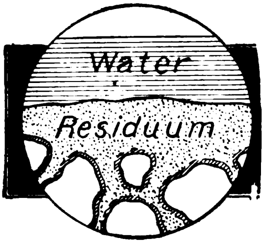


Fig. 12.—Showing how carbide may be shielded from water by residuum.

In the displacement system the pressure is determined and kept practically constant by the height of water about the bell containing the carbide, and the absence of levers and mechanical movements is a great point in its favor. An excellent type of this class of generator is shown in Fig. 13 and a section of the carbide holder is shown in

Fig. 14. The carbide is stacked upon a grate, not shown, which coincides with the acting water level. The residuum falls through the grate to the bottom of the generator and is withdrawn through a draw gate provided for the purpose. The lever on the gasometer bell shown in Fig. 13 acts simply to operate a displacement plunger, which increases the height of the water seal between the generator and gasometer and cuts the latter off from the former when the bell is full of gas. A little rod project-

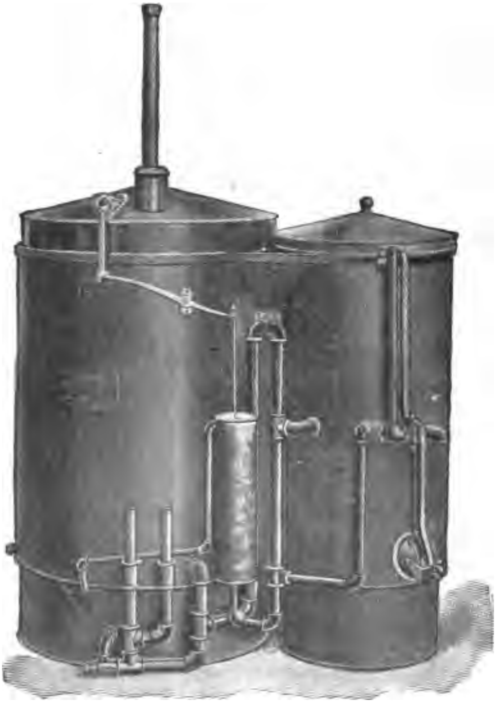


Fig. 13.—North light acetylene generator, "clean surface" principle. Pan-American Acetylene Co., Buffalo, N. Y.

ing from the generator shows by its height the state of the carbide charge.

Another generator using the displacement principle is illustrated in Fig. 15. In this generator the carbide is placed in a drawer carrying a wire grating on its mid section. The drawer is slipped into a compartment provided

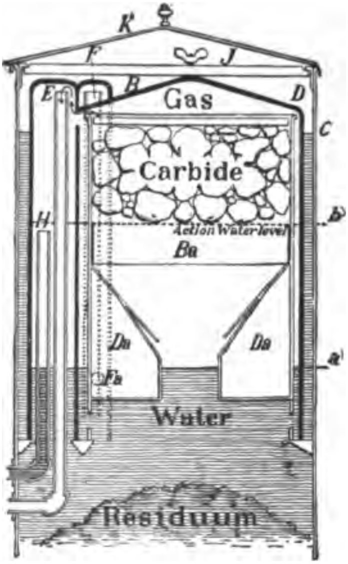


Fig. 14.—Section of carbide holder of "North Light" generator.

for it, the opening of which is covered by a gas-tight door. The water attacks the carbide from beneath on the displacement principle and the gas passes to the gasometer bell above. The drawer compartment is surrounded without with the water, which seals the gasometer bell, and, as this body of water is quite large, the generating chamber is very cool. The residuum is caught in the lower part of the drawer and it is but the matter of a moment to withdraw. The water level is very delicately

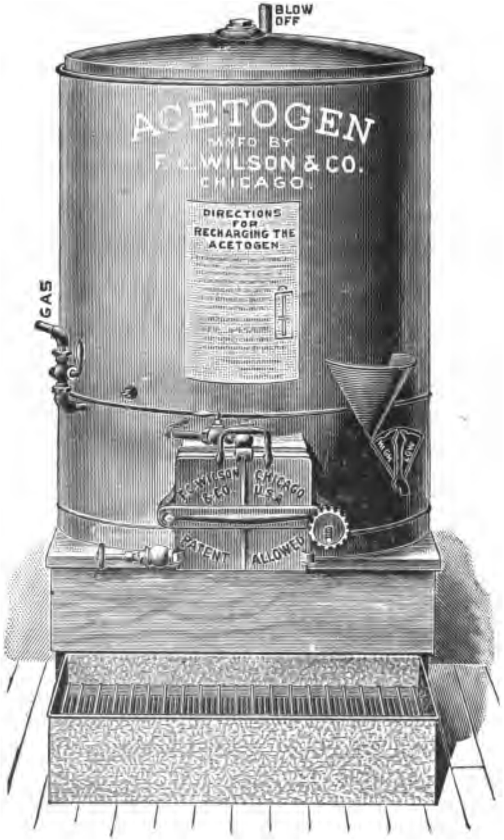


Fig. 15.—Generator and carbide drawer, displacement principle.

maintained in this generator, and varying generation is said to be attained by the contact of the water with more or less carbide, and not by the abrupt advance and recession of the level. This constant contact of a large body of water should make the process very cool.

An objection to generators of the displacement type is that they require large lumps of carbide and cannot handle carbide dust, which is found in some quantity in any shipment, and which would not be retained by the supporting grate. It is, however, one of the coolest processes used and consumes the carbide charge very thoroughly, as the mass is freed from residuum as fast as it is formed—a very great advantage.

Another among the forms of carbide generators is the plunger type, in which the carbide is fed in small quantities to a large body of water. The process in itself has much to recommend it. It is exceedingly cool, perhaps the coolest of all, and the carbide is very thoroughly hydrated, but difficulty is sometimes found in handling and feeding the carbide. Coming as it does in lumps of irregular sizes, it is apt to stick and clog any but the most ingenious mechanisms. As a rule most generators of this class use granulated carbide and avoid large lumps. Several of them are illustrated beyond and the reader can readily judge their relative merits.

In the first of these generators to be described, which is shown in Fig. 16, the generator and gasometer are placed side by side. The carbide is placed in a large hopper on the top of the generator and the motion of the gasometer bell feeds it into the water below, feeding when the bell falls and checking when it rises under the influence of the gas generated. The residuum is withdrawn through a valve below, shown at the right of the cut. This generator has an advantage which is common to all of its class, that it may receive a relatively large charge and make long runs without attention. It is as easy to care for as a stove. Carbide is added above and lime is withdrawn from below.

Another generator utilizing the same principle and possessing the same advantages inherent to the process is shown in Fig. 17. The carbide is fed from a hopper into water by the movement of a toothed wheel actuated by the gasometer bell. The diagram of the apparatus shown in Fig. 18 may serve to illustrate it more plainly. The residuum is drawn off through the valve R, which is preferably connected to the sewer, and an agitating plate S as-

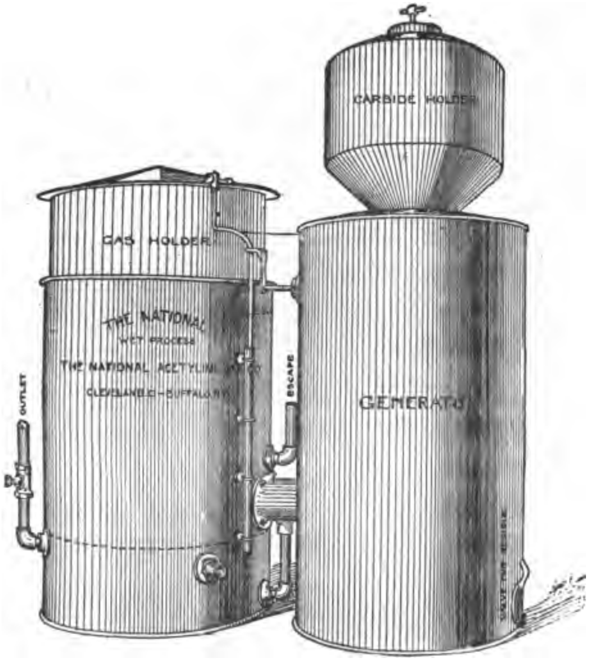


Fig. 16.—Generator operated on the plunger principle, dropping the carbide in the water.

sists the lime to mingle with the water, forming a semiliquid, which readily flows off. The liberated gas rises through the water and is washed and cooled and then passes over to the gasometer, but cannot reach the bell till it has passed through the charcoal purifier L. On this generator, gauge glasses are avoided by the use of little windows in the generator and gasometer tank, through which the level and condition of the contents can be readily observed. The generator uses granulated carbide.

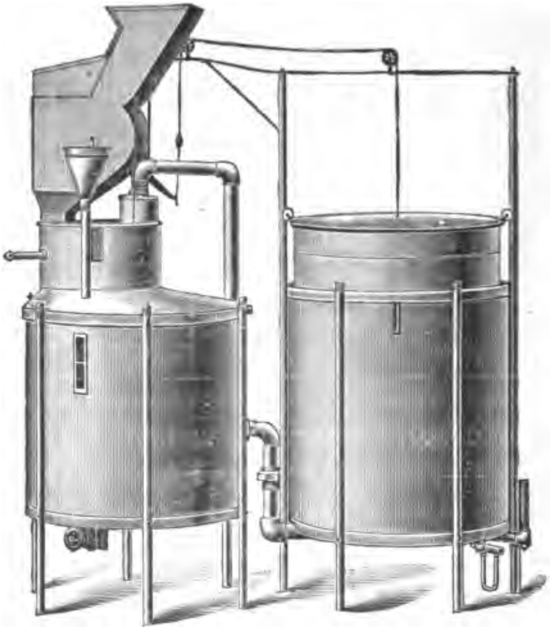


Fig. 17.—Bournonville generator, carbide feed plunger principle

Still another generator of the plunger principle, but of a totally different type, is shown in Fig. 19. The feature of this generator is the method by which it is fed. Over the large body of water in the generator is revolved a horizontal wheel with pockets, each carrying a suitable amount of carbide. As the wheel revolves under the influence of the gasometer bell the pockets are dumped and the charge falls into the water, thereby generating a defi-

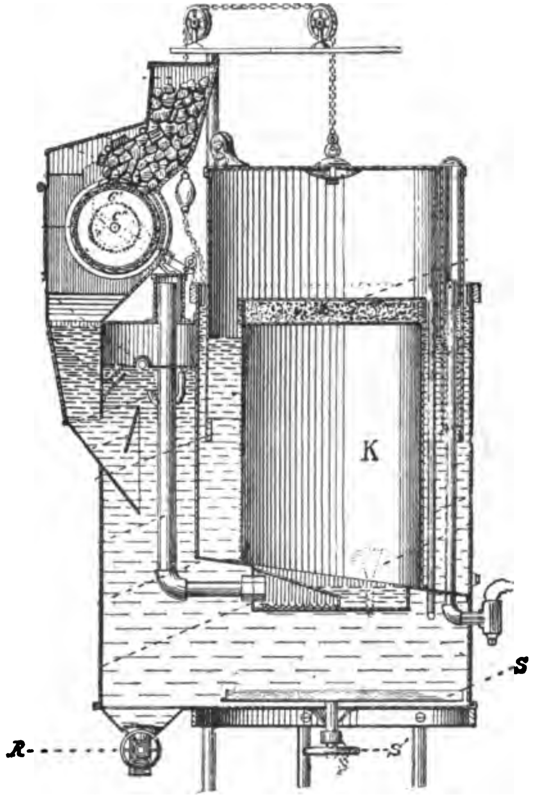


Fig. 18.—Diagram showing operation of Bournonville generator

nite amount of gas per feed. This generator has the advantage that it can use either lumps or dust, but it may be said that dust generates the gas very rapidly, almost explosively, and hence might cause momentary commotion in the generator. The pockets must of course be so designed that there is no chance for the carbide to wedge and fail to fall.

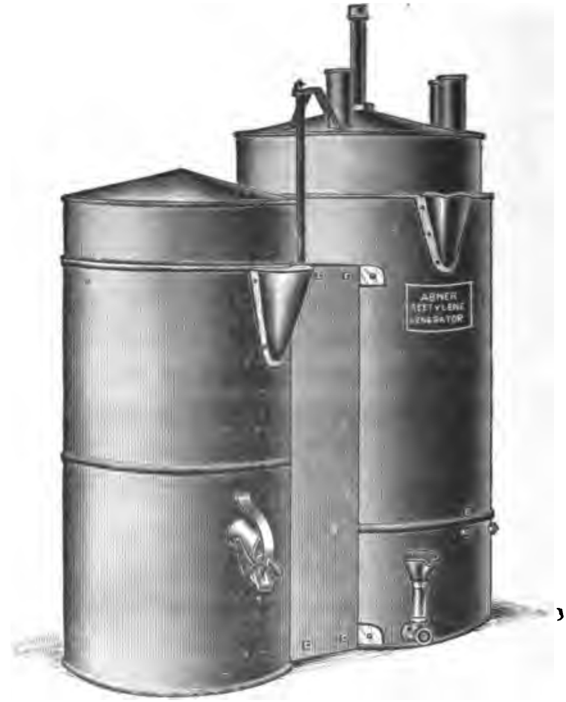


Fig. 19.—Plunger type of generator, dropping a definite amount of carbide at each feed.

Another class of carbide generators utilizes the principle of raising and lowering a metal cage of carbide into water, the motive power, of course, being derived from the gasometer bell. These generators use lump carbide and are, when properly designed, quite effective. Generators built on this plan are always very simple. The carbide is usually placed in a cage hung within the gasometer bell.

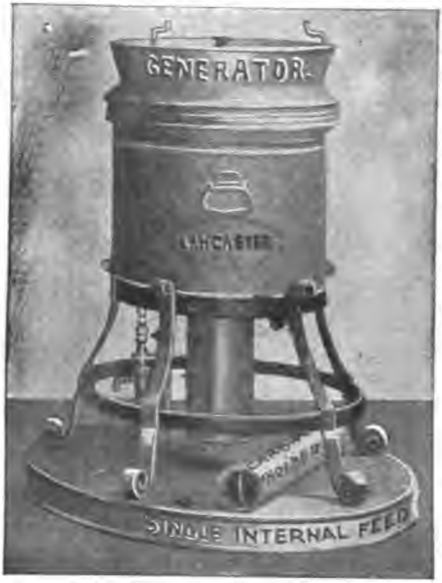


Fig. 20.—Generator on the immersion principle; carbide is lowered into the water and withdrawn.

When the latter descends the charge is immersed in the water, gas is immediately generated and the receiver is forced up again, carrying the cage of carbide with it. Such a generator is usually provided with several carbide holders, so that the loading is confined to simply exchanging the holder. Most machines of this type require that the bell be taken out, in order to renew the charge. The Lancaster generator, shown in Fig. 20, can be charged from the outside without the removal of the bell.

The detail of the Lancaster generator is worthy of a little more extended description. The carbide holder is removed through the top of the gasometer bell. It consists of a cylinder with a closed bottom and with holes punctured in the sides at the proper level. When this holder is lowered into the water below the holes, water flows in and attacks the carbide, generating gas and lifting the bell, which in turn lifts the holder, so that the water no longer enters it. The gas leaves the holder by a pipe which enters the top of the gasometer bell. This pipe carries a plug cock, which is shut off when it is desired to renew the carbide, thereby preventing any escape of gas from the bell. The single generator illustrated in Fig. 20 is intended for very small installations. The duplex form enables the renewal of one gasometer while the other is in operation.

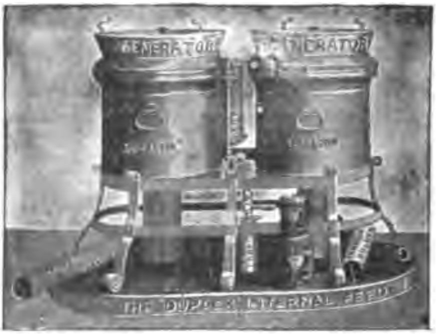


Fig. 21.—Duplex "immersion" generator.

The plug cock which shuts off the carbide holder from the gasometer bell is a very ingenious affair. It contains a little safety valve which prevents gas from flowing from the gasometer bell, but allows gas to flow from the carbide holder into the bell. This feature at first sight seems unimportant, but in reality it obviates one of the most serious difficulties with acetylene generators that use carbide in closed holders. When the holder is shut off preliminary to opening it, it is of course sealed tight, and before it can be opened it is possible that a sudden flush of gas may raise the pressure to very high figures. Indeed this has frequently happened, in many cases causing the carbide holders to leak, and in some cases even bursting pressure has been attained. This valve is adopted by Mr. Lancaster in all his generators, even the larger sizes, which are on the water dripping principle, and one of which is illustrated in Fig. 22.

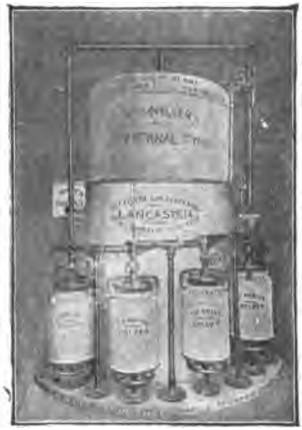


Fig. 22.—Large Lancaster generator, drip principle.

Another feature which is used on the Lancaster generators, and which is exceedingly ingenious, is the purifier.

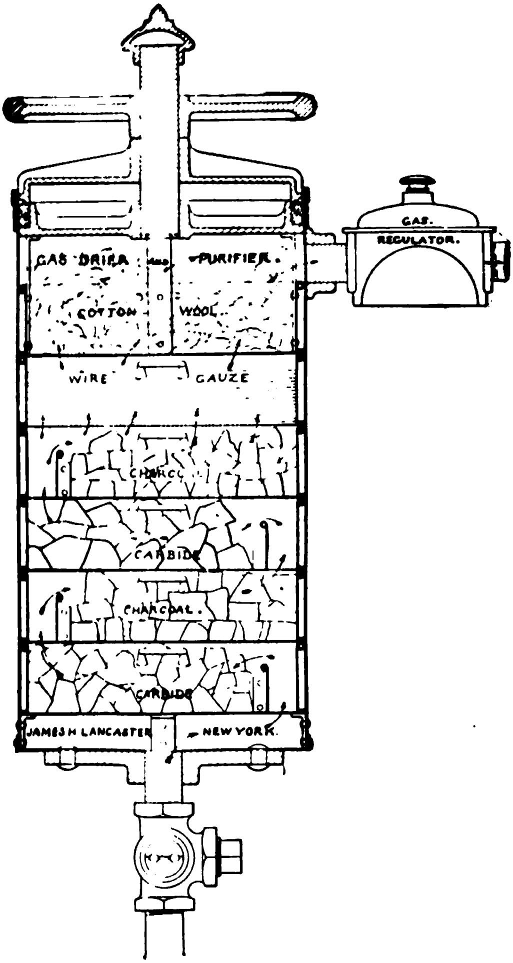


Fig. 23.—Lancaster purifier; carbide is used as a dryer.

The newly generated gas is forced through a cylindrical receptacle containing layers of charcoal and also layers of carbide. The latter, by reason of its great affinity for water, effectually dries all the gas which passes through it. It requires only occasional renewal, and the carbide thus used in the purifier makes gas which passes along with the main body of gas and is consumed. It is therefore not wasted, and, in short, performs the double office of generating and drying. This purifier is shown in Fig. 23.

INSURANCE RULES.

The various boards of underwriters throughout the United States have adopted sets of rules regarding the construction of acetylene generators and the handling and storing of calcium carbide. As it is important for the purchaser of a generator to know these rules, in order that he may not pay increased premiums, there is herewith listed a selection of the most pertinent rules from the best codes:

1. The apparatus must be made of steel and in a manner to insure stability and durability.

2. It must have sufficient carbide capacity to supply the full number of burners during the maximum period for which they will be needed.

Note.—This rule removes the necessity of recharging at improper hours. Acetylene generators should be charged in the day time, when there is no need of an artificial light.

3. It must be uniform and automatically regulating in its action, producing gas only as immediate consumption demands, and so designed that the gas is generated without excessive heating at all stages of the process.

Note.—The detrimental effects of heating have been touched upon in the preceding pages.

4. Apparatus not requiring pressure regulators must be

arranged so that the gas pressure cannot exceed three inches of water. It must be provided with an escape pipe, which will operate in case of over-production of gas, and also an attachment acting as an escape or relief in case of abnormal pressure in generator. An escape pipe carrying such excess of gas must be at least three-quarters of an inch in diameter and lead to a suitable point on the outside of the building, discharging at least 12 feet from the ground level, and provided with an approved hood.

5. Apparatus requiring a pressure regulator must be arranged so that the gas pressure cannot exceed three pounds to the square inch, and must have a safety blow-off attachment located between the pressure regulator and service pipes, the blow-off being subject to the same specifications as in rule 4.

6. It must be arranged so that when being charged the back flow of gas from the holder will be automatically prevented, or, if preferred, it may be arranged so that it is impossible to charge the generator without first closing the supply pipe to the holder and to other generating chambers.

7. It must be arranged so as to contain the minimum amount of air on start, and must be so designed that mixtures of air and gas are impossible excepting at the burner tips.

9. Pet-cocks connecting with the gas holding part or parts will not be permitted. Condensation from all parts must be automatically removed without the use of valves or mechanical devices.

10. The water supply to the generator must be such that the gas will be generated long enough in advance of the exhaust of the supply in the gas holder to allow the using of all the lights without exhausting such supply.

11. No carbide chamber of over 25 pounds capacity

shall be allowed in any machine where water is dripped in small quantities or where contact with carbide is intermittent. This applies to all machines excepting those which drop the carbide into the water.

12. Generator must be connected to the gas holder so that it will at all times give connection to the gas holder or blow-off tank to outer air.

13. It must be so designed that the lime residuum will not clog or affect the working of the machine.

14. Covers to generators must be securely fastened in place, and in those using a water seal the seal cavity must be at least 1½ inches wide and 15 inches deep, excepting those that depend upon the seal for the generation of gas, when 9 inches will be sufficient.

15. Holder must be of sufficient capacity to contain all gas after all lights have been extinguished. This prevents the surplus gas from blowing off to the outside.

16. The bell portion of the gas holders must be provided with a suitable guide for its upward movement, and a stop acting about 1 inch above the blow-off point.

17. A space of at least ¾ of an inch must be allowed between the sides of the tank and the bell.

18. All water seals must be so arranged that the water level may be easily seen and maintained.

19. Gas holders constructed upon the gasometer principle must be so arranged that when the gas bell is filled to its maximum its lip or lower edge shall at all times be submerged in at least 9 inches of water.

20. The supply of water to the generator for generating purposes shall not be taken from the water seal of any gas holder constructed on the gasometer principle.

21. The apparatus shall be capable of withstanding fire from outside causes without falling apart or without allowing the escape of gas in volume.

Note.—This bars joints relying entirely upon solder.

22. Gauge glasses, the breakage of which would allow the escape of gas, shall not be permitted.

23. Purifiers, when used, must conform to the general rules of other apparatus and allow the free passage of gas.

24. The use of mercury seals is prohibited.

25. Liquid seals of any kind must be so constructed that they cannot become thickened by the deposit of lime or any other foreign matter.

26. Apparatus must be so constructed that accidental syphoning of the water is impossible.

27. Flexible tubing, swing joints, packed unions, springs, chains, pulleys, stuffing boxes and lead or fusible piping must not be used on the apparatus except in such cases where failure thereof will not affect the working or safety of the machine.

28. Each machine must be plainly marked with the maximum number of lights it is designed to supply and the amount of carbide necessary for a single charge.

To be approved, acetylene generators must conform to the foregoing standard, and plans and specifications in detail of such apparatus must be submitted to the insurance organization having jurisdiction over the territory in which such apparatus is to be installed. If the plans are approved a special examination will be made at the expense of the applicant, and if found to be satisfactory a certificate of approval will be issued.

CALCIUM CARBIDE.

1. Calcium carbide must never be stored in bulk.

2. It must be packed in screw top water-tight boxes having all seams soldered. They shall not contain over 125 pounds of carbide each, and must be conspicuously

marked "Calcium Carbide; keep dry." They must be sufficiently strong to insure handling without damage, and they must be kept under shelter at all times.

The user of an acetylene generator is usually called upon to guarantee that the following rules for manipulation be observed:

1. That carbide shall be charged and handled by daylight only.

2. No direct fire, heat or artificial light shall be allowed in the room containing the apparatus.

3. Calcium carbide shall not be kept in the building covered by the policy.

4. No greater number of lights shall be installed than the maximum for which the machine is rated.

5. No change shall be made in the installation without the written consent of the insurance company.

It may also be stated that the use of liquid acetylene or gas generated therefrom is absolutely prohibited.

The following cautions are usually appended to the insurance rules and must be observed:

1. Calcium carbide should be kept outside of any insured building, under lock and key, and where it is protected from the weather.

2. A regular time should be set aside for attending to and charging the apparatus during daylight hours only.

3. In charging generator chambers, clean all residuum therefrom and remove at once from the building. Be careful never to fill any container to which water is added by the process of generation over half full, for the carbide swells when it comes in contact with the water.

4. Never place carbide in the containers until all residuum shall be removed.

5. Keep all water tanks and water seals filled with clean water.

6. Where apparatus is not intended for use throughout the year, all water must be removed at the end of the season.

7. Never use a lighted match, lamp, candle or any open light near the machine.

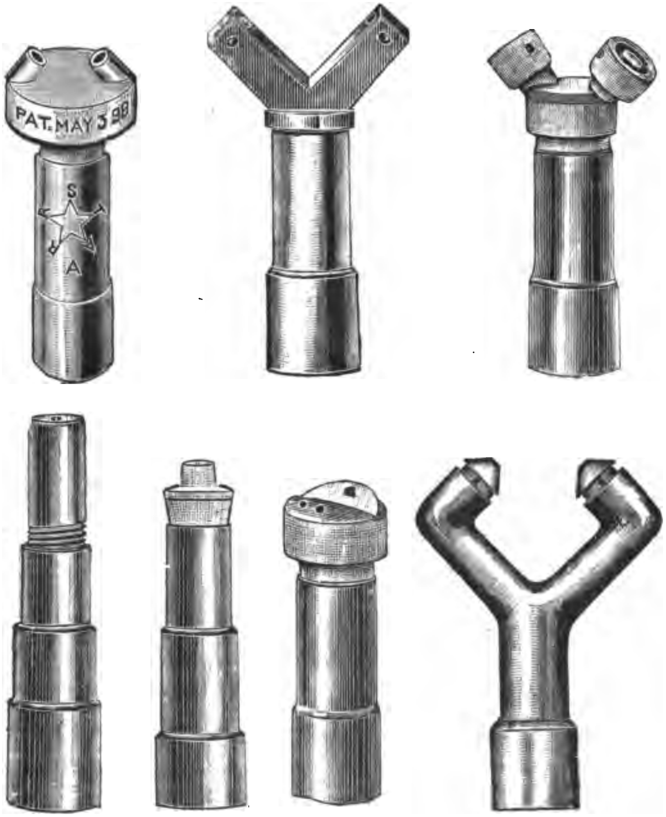
Having generated the acetylene, it remains to properly distribute and burn it. A gas piping system such as has been described and illustrated in the preceding chapters of this book will answer, provided it is tight, but ordinary gas tips will not be suitable. Figures 24 to 30 show types of tips suitable for acetylene jets. They consume about half a cubic foot per hour, and differ from ordinary tips in that they admit more air to the flame, and in fact intermingle the gas slightly with the air before ignition takes place. The gas is rich in carbon, and the hydrogen it contains, together with a sufficient amount of air, renders its particles of carbon brilliantly incandescent and consumes them completely, therefore giving no smoke. The product of the combustion is carbon dioxide and watery vapor, the action being as follows:

$$C_2H_2+5O=2CO_2+H_2O$$

acetylene+oxygen=carbon dioxide+watery vapor.

Acetylene burns with a pure white flame and undoubtedly gives the best light of any hydrocarbon illuminant, and one closely approaching that of the sun in quality, so closely indeed that the most delicate colors can be accurately matched under its rays. It contains most of the qualities of pure white light and its spectrum compares most favorably with that of sunlight. The diagram Fig. 31 shows the comparison conveniently. Three curves are shown, those of city gas, acetylene, and sunlight. The close comparison of the two latter will be noted at once.

The gas flame is rich in heat rays, as shown by the length of its ordinates at the left of the diagram, while acetylene and sunlight are rich in luminous and actinic rays, the latter being shown at the right of the diagram. Actinic rays are those which favor chemical change and vegetable growth, and on account of its rich character in this re-



Figs. 24 to 30.—Types of acetylene gas tips.

spect acetylene is an admirable light for photographic purposes, and pale, sickly vegetable shoots rapidly become green and flourish under its influence.

With regard to the relative brilliancy and candle power values of acetylene and illuminating gas, it is hard to give figures that cannot be criticised. That acetylene has many times the illuminating power of ordinary gas there is no room for doubt. This is prettily shown by Fig. 32, a photograph of a ½-ft. acetylene burner and a 6-ft. burner using city gas. The plate was the same in each case, as was also the time, one second. The result speaks for itself, though it may be mentioned that the picture is perhaps a more effective demonstration of the actinic rather than the luminous qualities of the light, and shows its adaptation to photography.

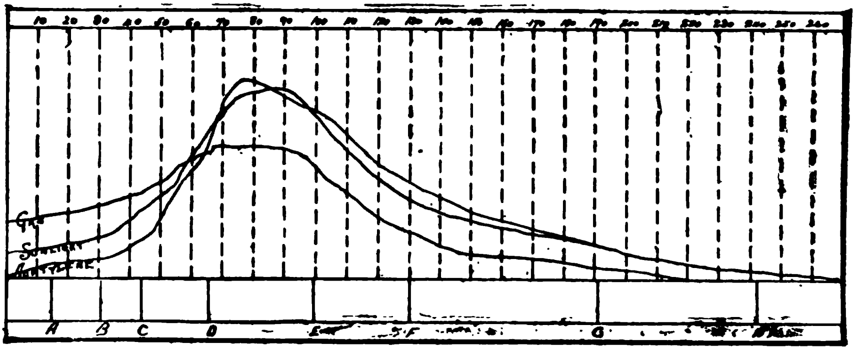


Fig. 31.—Curve showing the luminous properties of city gas, sunlight, and acetylene.

Returning to the relative value of the illuminating power of gas and acetylene, it has been measured by different authorities, and the results vary exceedingly, some stating that acetylene has 25, or even 50, times the illuminating power that gas possesses, while others place the factor as low as 12. There are different qualities of both city gas and acetylene, and it is not surprising that comparisons vary. It may be conservatively assumed that acetylene is fifteen times as luminous as gas, that is to say, there are fifteen times as many candle power hours in one cubic foot of acetylene as there are in one cubic foot of gas. It may also be assumed that there are 50 candle power hours in one cubic foot of acetylene gas, and therefore a ½-ft. burner gives 25 candle power. Assuming the ratio fifteen to hold, a cubic foot of city gas contains 3⅓ candle power hours, making a 6-ft. burner of 20 candle power, which is closely the fact.

Knowing that one pound of carbide will produce 5 cubic feet of acetylene, and assuming the possession of a generator which will convert it all—a rather liberal assumption—we only need to fix the price of carbide to draw comparisons.

Fig. 32.—Photograph of acetylene and city gas tips on the same plate. Time, one second.

Carbide varies in cost from 20 to 3½ cents per pound. In ton lots it may be bought at $70, but for 1 hundredweight $5 must be paid. From these figures the following table may readily be computed:

Cost of Carbide per lb.	Cost per M ft. of Acetylene.	C. P. Hours for $1 00.	Equivalent price on City Gas per M ft.
.05	$10 00	5000	66⅔
.04½	9 00	5555	60
.04	8 00	6250	53⅓
.03½	7 00	7143	46⅔

It is doubtful if these figures could be absolutely realized owing to waste of carbide and gas, but there is little doubt that the process could be conducted so that the equivalent price of city gas would be $0.70 where 5-cent carbide was used, and perhaps $0.50 gas might be replaced with carbide at 3½ cents. These figures for gas are certainly an attraction anywhere except in large cities having many companies and a gas war in progress.

Considering the cheapness of the illuminant and its brilliant, steady light of superior quality, its permanent success seems certain. Acetylene has by many interested parties been charged with many obnoxious properties, and perhaps a word upon the truth concerning these matters may not be out of place. First, it has been described as odorless, poisonous, and hence highly dangerous, and such indeed would be the fact if this were so. It is not good to breathe any more than ordinary illuminating gas, but as its odor is exceedingly pronounced and very disagreeable, it tends to nauseate, and, it is said, will even awaken a sleeper. If this be true, it has a pronounced advantage over illuminating gas, the narcotic properties of which are well known. Acetylene has been also accused of emitting as a product of combustion carbon monoxide, a highly poisonous and odorless gas. This is not the fact, for if proper burners are used the products of combustion are carbon dioxide and watery vapors, exactly the products of human respiration. Indeed, ordinary illuminating gas is more likely to burn to carbon monoxide than acetylene, and, as further offensive products of combustion of city gas, often produces sulphur dioxide and ammonia, whose destructive action on decorations and delicate fabrics calls for no comment.

The relative amounts of CO_2 generated by an acetylene flame and one of illuminating gas of equivalent candle power has been extravagantly misrepresented. For every foot of acetylene burned 15 feet of illuminating gas must be burned to produce equal candle power hours. Both gases are hydrocarbons, the acetylene being pure and the illuminating gas a mixture of various polymers. It is sufficient to say that the amount of carbon by weight in acetylene and illuminating gas is roughly the same per cubic foot. It therefore follows that for equal luminous effect there would be much more carbon dioxide generated by illuminating gas. As a matter of fact the ratio is one volume of CO_2 by acetylene to six volumes of CO_2 by illuminating gas at equal candle power. The following table, due to Prof. V. B. Lewes of London, shows the vitiation of air in a room by different illuminants on the basis of equal illumination:

Source of Light.	Amount Used.	Carbon Dioxide produced.	Equivalent number of Adults.
Sperm Candles..	48 Lights.		32.7
Paraffin Lamps..			22.5
Flat Flame, No. 4	25.8 cu. ft.	13.4	22.3
" " No. 5	22.9 "	12.1	20.1
" " No. 6	19.2 "	10.1	16.8
London Argand.	15 "	7.9	13.1
Acetylene.......	1 "	2	3.6

Acetylene has also been criticised as explosive, and a word concerning this property is necessary. Like any hydrocarbon, it is explosive if mixed with a proper volume of air, the most violent explosions being produced at mixtures of about 12½ per cent. of acetylene—in fact, the same as for common gas. Acetylene, however, has an advantage in the size of the tip. Where a 7½-ft. burner of common gas might, if left open, produce an explosive mixture in ten hours, an acetylene burner of equal candle power would require 150 hours to produce a mixture equally explosive.

Explosions have sometimes occurred in generators constructed on the pressure principle with improper relief valves, but such explosions cannot be charged to the explosive properties of acetylene, although this has sometimes been done by ignorant or interested parties.

Acetylene burns best from a ½-ft. tip; larger tips are not as satisfactory, and unless carefully made combustion is apt to be incomplete. It is therefore advisable when desiring to increase illumination to increase the number of tips rather than to install those of larger candle power. This has also the advantage of distributing the light. It is well known that a great objection to arc lighting for interior work is the intense concentration at one point, thereby lighting one part of the room very brilliantly and filling others with dark shadows. By subdividing the light into small portions and distributing them about the room, much better results are obtained. Ingenious arrangement will also minimize shadows, and may even eliminate them.

For heating purposes, acetylene has not been largely used. When mixed in proper proportions, like most hydrocarbons, it burns well in burners on the Bunsen principle; it burns with a very hot flame, and stoves thus equipped have been offered for sale. Acetylene has no advantages over ordinary gas for heating purposes, because luminosity is no longer desired, and in heat units per cubic foot of gas city gas is an exceedingly close competitor. As acetylene gas costs from seven to ten dollars per 1,000 feet, it is obvious that it is at present out of the heating market so long as an equal volume of city gas will heat just as well.

This chapter would hardly be complete without a few figures whereby a prospective user of acetylene can estimate the cost of fitting his house to burn that illuminant. Generator prices vary widely, and the following table is a fair average:

NO. OF ½-FT. TIPS.	PRICE.
5	$50.00
10	65.00
15	80.00
20	90.00
30	120.00
40	135.00
50	150.00

Of course it is to be understood that generators vary in price according to the principle on which they are constructed, and also according to the details of their design. As a rule those using the water drip principle or the displacement principle cost about alike. Those using the cage principle, in which the carbide is carried in a gasometer bell, are a little less expensive, while those in which the carbide is fed into the water are generally the most expensive of all. Gas piping suitable for acetylene work in ordinary dwelling houses costs about 15 cents per running foot installed, and acetylene tips are worth 25 cents each. Side brackets may cost all the way from 30 cents to $5 each, while hanging fixtures range from 50 cents each to several hundred dollars.

It is easy to see that one can go to almost any expense on fixtures, because of the many different degrees of ornamentation and decoration which they involve. From the above can be obtained an idea at least of the cost of installing an acetylene plant. To these figures, however, should be added the cost of running a waste or blow-off pipe outside the house and providing a small uninsured shed in which to store carbide; and it may be added in closing that if the prevailing rates for city gas exceed $1.20 the installation of an acetylene plant will not only secure better light at less cost, but the expense will be so much reduced that interest on the original investment, and even the principal itself, will be recovered in time.

YC 68228